Illinois State Geological Survey Annual Report

May 1986–April 1987

Illinois Department of Energy and Natural Resources
STATE GEOLOGICAL SURVEY DIVISION

ANNUAL REPORT
to the
BOARD OF NATURAL RESOURCES AND CONSERVATION

May 1986 to April 1987

Cover: Pamella K. Foster

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1986 HIGHLIGHTS AND SUMMARY

MINERAL RESOURCES

- The total estimated value of Illinois mineral production in 1986 was about $2.6 billion, 13.6 percent lower than in 1985. The decrease essentially resulted from a decline in oil production and a significant decrease of almost 50 percent in the price of oil.

- New efforts to assess Illinois' mineral resources include a joint ISGS/USGS venture, the Conterminous U.S. Mineral Assessment Program (CUSMAP), which was initiated in October 1986. This new mapping program, including the Paducah 1° x 2° sheet, covers all of Illinois south of the 38th parallel--the approximate latitude of Benton and DuQuoin. CUSMAP complements the ongoing ISGS/USGS COGEOMAP program that is delineating new coal reserves in southern Illinois. In a third ISGS/USGS study, a north-south subsurface geochemical transect of Illinois has revealed anomalous values of metals--geochemical signatures of four major ore deposit types in Illinois. Further in-depth studies are warranted.

- Two research methods for removing sulfur in coal, the ISGS Aggregate Flotation Method for removing pyrite and ash and the CO/Ethanol Method for coal desulfurization, have shown sufficient promise to warrant scale-up from laboratory batch mode operations to larger, continuous modes of operation.

Coal

- Coal remained the most important mineral in Illinois with an annual value of about $1.86 billion. Coal production increased by about 3.5 percent to 62.6 million tons; however, coal exploration reached a new low point.

- The Survey's open files of coal information have been significantly expanded: hole records, geophysical logs, and core descriptions have been added; many of them were released from confidential files. Work is underway to encode detailed coal resource information for a computerized system to manage and analyze coal resource data.

- A new report has been prepared (Circular 540) identifying 1.17 billion tons of Herrin No. 6 Coal in the Hornsby area in central Illinois. This area, relatively untapped, is expected to contain coal with less than 2.5 percent sulfur, possibly as low as 1 percent. Other coal resource studies are underway in a seven-county area in southern Illinois and a large area extending from east-central Illinois into west-central Indiana.

- Two computerized systems for managing information on coal mining geology are under development--one to handle stratigraphic data, the other to handle coal mine information. Mined-out-area maps can now be produced by computer.

- The Survey is cooperating with the USGS by supplying computerized data on the quality of Illinois coal to a national database, the National Coal Resources Data System (NCRDS).

- Mineral impurities in coal, along with various ionic species generally deleterious for steam generation at electric power plants, are receiving new attention. Results show that chlorine is concentrated in the organic portion of coal, probably in micropores. Water leaching proved to be the most effective and practical technique for removing chlorine from finely pulverized coal, but it is relatively ineffective for large coal particles at room temperature. Sodium occurs mainly in the clay minerals and can be removed by cleaning processes that separate mineral and coal particles according to their densities.

- A new study was initiated to investigate the electrostatic charges of fine coal particles. Results so far suggest that the surface of fresh coal samples is positively charged under natural pH conditions and thus can adsorb significant amounts of the chlorine ion. Monitoring the surface charge and if necessary, altering it using surfactants, should increase the efficiency of surface-dependent coal-cleaning processes.

- Modernization of the Coal Analysis Laboratory through Coal Development Board awards, "Build Illinois" funds, and industry donations has created one of the most up-to-date laboratories of its kind. New equipment includes a proximate analyzer, an ultimate analyzer, a UV-VIS spectrophotometer, an atomic absorption spectrophotometer, an ion chromatograph update, an integrator for use with the ion chromatograph and the Carlo Erba CHN analyzer, and an IBM PC for data management. The Coal Analysis Laboratory and Thermal Analysis Laboratory together provide the Survey with the powerful analytical capabilities needed for in-depth coal research.

- A sixth sample, an Indiana coal, was added to the Illinois Basin Coal Sample Program. This program, supported by the Coal Development Board, provides a coal bank of representative, uniform, preserved samples for use by researchers. A computer database to incorporate chemical, petrographic, and mineralogical data on these samples was completed this past August.

- Results continue to confirm the advantages of the ISGS Aggregate Flotation (AF) techniques over conventional froth flotation techniques for cleaning fine-sized coal. The AF process yields a product that exceeds 80 percent Btu recovery while rejecting more than 80 percent of the ash and pyrite. Promising proprietary compounds have been produced by SIU in a collaborative research effort that reduces the dosages normally required to produce good Btu recovery. Planning has been initiated for commercial testing of the AF process.

- Ways are being investigated for improving the direct capture of sulfur dioxide from coal combustion through injection of calcium-based sorbents into the furnace cavity of existing coal-fired boilers. Sulfur dioxide sorption activities were determined for various methods of hydrating lime or limestone. Limes hydrated with a methanol-water solution were found to have sorption capacities equal to or greater than commercially prepared pressure-hydrated limes. This suggests that costs associated with pressure hydration can be eliminated by hydration with methanol-water solutions at atmospheric pressure.

- Thermal methods of desulfurizing coal are actively being pursued in an aggressive research program. Hydrodesulfurization of preoxidized chars yielded better results than hydrodesulfurizaton of nonoxidized chars. Further

research has shown that a magnetic iron sulfide can be produced by heating chars in a slightly oxidizing atmosphere at about 550°C and that the resulting sulfide mineral can be removed magnetically. Combustion characteristics of thermally altered coals are being determined at three levels of partial devolatilization. Work is underway to determine the best combination of methods and techniques for the thermal and magnetic desulfurization of Illinois coals.

- Experimental work has indicated that the carbon-monoxide/ethanol method of coal desulfurization has the potential to remove more than 90 percent of the total sulfur from Illinois coal. The process involves three steps: (1) introducing carbon monoxide at 300° to 350°C to produce carbonyl sulfide, hydrogen sulfide, and a catalyst troilite (FeS) from pyritic minerals (FeS_2); (2) treating the coal with ethanol at 350° to 550°C to form acetaldehyde and H_2S through a dehydrogenation process in which atomic hydrogen reacts with the organic sulfur; and (3) producing oxidizing conditions to convert the troilite catalyst to a magnetic form of iron sulfide that can be removed magnetically. Plans have been developed to scale-up the effort from a laboratory batch mode to a continuous reactor.

- While microbial removal of sulfur from coal chars has been demonstrated, the residence time of 27 days required to accomplish 89.6 percent pyritic sulfur removal indicates that the method is not commercially viable. However, microbially enhanced physical separation of pyrite may still be feasible through the impact of bacteria on the surface properties of the pyrite or the wetting agents used in pyrite removal. Research is proceeding on this aspect.

Oil and Gas

- The most serious short- and long-term energy problem in the United States has been identified as the inadequate supply of domestic petroleum for transportation fuels. The problem has recently been exacerbated by the price collapse in the oil industry, which led to an 80 percent decrease in rig count in Illinois, a 60 percent decrease in the monthly average of drilling permits, and a 20 percent reduction in the average monthly production for the period of July-December 1986. Similar effects have been felt in other oil-producing states. The result nationwide is a rapidly widening gap between consumption and production with demand outstripping domestic supply. Forecasts indicate adverse effects on the nation's balance of payments, security of supply, and defense needs.

- The Survey has expanded its research efforts in oil and gas, adding expertise in petroleum engineering and support help to update and modernize its oil and gas database. Greater emphasis is being placed on research to improve the recovery of hydrocarbons from existing fields, and work is continuing in research on developing new concepts and techniques for locating subtle traps. Significant additions have been made to the Survey's database of reflection seismic profiles.

- A scanning electron microscope (SEM) and a new X-ray diffraction unit have been added to study the physical and mineralogical nature of Illinois' reservoir rocks. Significant differences in clay content, types of clay minerals and cementing minerals, and manner of occurrence have been revealed in several reservoirs. These characteristics may influence porosity and permeability, which influence completion techniques and suitability for secondary and tertiary recovery techniques.

- In studies of reservoir heterogeneity, clay mineral content of the Aux Vases formation has been found to contribute to poor well completions and rapid declines in oil production. Wide variations in clay mineral content that have been found in other strata range from pure chlorite to fibrous illite, to vermiform kaolinite, and to smectite. Their reactions to acid stimulation will vary, affecting the choice of well completion and well stimulation practices.

- Research on subtle traps has indicated that (1) stratigraphic traps in the Aux Vases depend on lateral changes in grain size and unit thickness; (2) the largest oil accumulations in the Silurian carbonate strata of Brown and Schuyler Counties occur in subtle paleovalleys eroded in the underlying Maquoketa shale; (3) many of the traps in Pennsylvanian sandstones are associated with sediments deposited in paleovalleys eroded in pre-Pennsylvanian strata; and (4) Silurian pinnacle reefs were originally distributed across a much larger portion of Illinois than the present producing trend indicates.

- Extensive studies are underway to characterize the nature of petroleum source rocks and correlate crude oil/source rock pairs. Source rock intervals that have been identified include the Middle Ordovician Guttenberg formation, Ordovician Maquoketa shale, and the Devonian New Albany shale. On the basis of geohemistry, the oils can be divided into two types: type one oils include the majority of Silurian and Devonian oils as well as all the younger crude oils; type two crude oils have common characteristics of Ordovician oils. Preliminary data indicate that type one oils originated from New Albany shales in southeastern Illinois, and type two oils may have originated from organic-rich Middle Ordovician shales.

- Gas well testing was provided as a service for 43 gas or gas/oil wells this past year. As a result of this effort, natural gas that would have been flared or shut in is now being put to use. One hundred fifty-two samples of natural gas collected in the field or submitted by gas producers were analyzed chemically to provide information on gas quality and to distinguish gas sources. A computerized database of gas analyses has been established.

Industrial Minerals and Metals

- The list of ISGS industrial minerals publications, arranged by mineral commodity, has been revised and will be published soon. Also, an overview of industrial minerals in Illinois has been prepared for inclusion in INHS Special Publication 6, "Natural Resources of Illinois: Introduction and Guide."

- All operating quarries in the Chicago area, together with most exposures, have been examined to establish the requirements of the stone industry and locate new sources of construction aggregate. Work has been extended to the subsurface. In addition, an inventory of all abandoned quarry sites in Cook County is nearing completion.

- Data on thickness, depth, character, and minability of near-surface limestones and dolomites are being compiled for several counties in central Illinois. This compilation should prove helpful in determining whether the local shortfall in construction aggregate can be eliminated by underground mining of thick pre-Pennsylvanian carbonates.

- ISGS/IDOT cooperative studies continue to evaluate the durability of carbonate rock aggregates and gravel deposits. Differences in rock type and physical and chemical make-up are being correlated with variability in freeze-thaw expansion conditions of cement in concrete highways.

- A pilot study of the subsurface geochemistry of insoluble residues from 29 drill holes has been conducted along a transect from northern to southern Illinois in a cooperative effort with the USGS. Regions of anomalous metallic values raise important questions about concepts and models of mineral occurrences in the subsurface of Illinois.

- CUSMAP, a new mineral appraisal program, was initiated in southern Illinois south of the 38th parallel in cooperation with the USGS and the states of Illinois, Kentucky, Missouri, and Indiana. Surface and subsurface data are being compiled in this 5-year program to evaluate the potential for fluorspar, barite, base metals, beryllium, thorium, rare earths, coal, oil and gas, industrial minerals, and groundwater.

- Preventing loss of ores in discarded fines is the subject of an investigation of mineral processing procedures. A paper has been prepared illustrating the impact of preventive and corrective measures including controlled grinding, intensive aeration, aggregation of particles, intensive mixing, increased retention time, and detachment of particles from bubbles during flotation.

Mineral Economics

- Information on Illinois mineral producers has been compiled in the recently completed 1986/87 directory.

- Mineral economic studies were completed dealing with the factors affecting the prices of fossil fuels in the United States, the feasibility of secondary recovery of coal from fine-coal wastes, the economic issues affecting mine-subsidence research, and the impact of acid-rain legislation on production of high-sulfur coal in six states and on sales of Illinois Basin coal. Under current environmental laws, sales of Illinois Basin coal will remain essentially unchanged until 1994 and may rise only slightly by the year 2000. If the acid-rain law is passed and implemented, sales could decline 30 percent by 1994 and 60 percent by 2000, unless measures to reduce costs and sulfur content are devised and successfully applied. Only concerted efforts to improve mine productivity and sulfur reduction offer alleviation of the threatened loss of coal production and jobs.

Framework Studies

- The Basin Analysis Task Force, formed to develop a sound framework for the Illinois Basin area is producing the Interior Cratonic Sag Basin volume, an AAPG-sponsored publication, as a part of its Petroleum Basin Series. Among other data on the origin, migration, and entrapment of hydrocarbons in cratonic sag basins, the volume will feature high resolution seismic reflection transects across major structural features.

Databases

- The Geological Records Unit continues to provide a vital database for industry, the public, and Survey scientists. Although drilling permits and visitor days decreased, file usage and number of orders for geologic records increased. Efforts are underway to consolidate pending and regular files and to proceed with overall computerization of the Unit's records.

- The Geological Samples Library added significantly to its collection of cores and cuttings. The number of visitors (287) using the facility in 1986 more than doubled the number for the preceding year. A significant number of visitors were from out of state (59%). The facility is providing a valuable database to attract investment in the State of Illinois.

ENVIRONMENTAL GEOLOGY

- Detailed geological, geotechnical, and environmental studies continue to show that the site adjacent to the existing Tevatron ring at Fermilab near Batavia, Illinois is a suitable site for locating the Superconducting Super Collider (SSC), a DOE-proposed $4.3 billion, high-energy physics facility.

- Solid advances have been made in assuring the adequacy of underground injection of some types of hazardous wastes.

- A new office was opened in Chicago's loop at the State of Illinois Center. The office will be involved in coordination and liaison activities involving the SSC, geotechnical engineering, drilling, mineral development, groundwater resources, waste disposal, and other matters of environmental concern requiring geological expertise.

Environmental Studies and Assessment

- The Environmental Studies and Assessment Section continues its involvement in the Long-Term Ecological Research (LTER) program. It is participating in a joint effort with the U.S. Army Corps of Engineers to plan a long-term resource monitoring effort for the Upper Mississippi River area.

Geology for Planning

- The Illinois Geological Survey has been active in developing a proposal to site the Superconducting Super Collider (SSC) in Illinois. A geological task force has investigated the subsurface conditions for a 52-mile elliptical tunnel and experimental areas in which the high-energy physics facility will be located. The ISGS has led an environmental task force made up of representatives from the other two scientific surveys, the State Museum, and DENR's Springfield office to locate an appropriate site for the facility. Efforts have defined a site that meets the necessary constraints for archeological or cultural sites, endangered species, and sources of surface or groundwater and is safe, stable, and secure.

- The SSC drilling program included 13 test holes this past year, bringing the total number of holes drilled to 30. Cores were taken from both the drift and bedrock for detailed descriptions and geotechnical analyses. All test

holes were geophysically logged. In situ stress measurements, which are an important consideration for the design of the rock chambers for the SSC experimental areas, were made. A down-hole TV camera recorded the wall characteristics in three, large-diameter (8 in.) boreholes.

- Geophysical studies for siting the SSC included both a refraction and a reflection seismic survey. The refraction survey indicated the nature of the glacial drift and the depth to and character of the bedrock. The high resolution seismic profile indicated the continuous nature of the bedrock between boreholes along an experimental 3-mile line.

- Geotechnical studies provided information on the strength of bedrock materials, the nature and direction of joints, the nature of in situ stresses, the thermal conductivity of rock samples, and other engineering data of importance in the design and construction of the SSC facility.

- An "Environmental Screening Atlas" containing 41 maps was compiled illustrating the data that are being used in computer modelling for the optimal location of the SSC with respect to environmental, cultural, and geotechnical constraints.

- Studies of background level of natural radioactivity of geologic materials and of groundwater were also undertaken as part of the investigation of SSC sites. The disposal of excavated material from the SSC project area was also studied.

- While major effort was devoted to the SSC, other geology-for-planning projects included: (1) a Perry County study to provide geologic information for coal mine planning, construction, and operation; (2) the development of a plan to assist the Argonne National Laboratory in characterizing the vibration-transmitting qualities of geologic materials in which a 6 GeV synchrotron ring will be located to ensure stable and secure foundations for the project; and (3) the development of a program of research on important geologic factors affecting the potential for high indoor concentrations of radon.

Waste Management

- A prototype version of a field-scale earthen liner for a landfill was successfully constructed to determine the best methods of instrumentation and whether infiltration criteria could be met. The prototype provided valuable information on the hydraulic, engineering, and chemical properties needed to design the field-scale liner to be built this summer.

- Research and service efforts are underway on a number of projects to define the impacts of contaminants on groundwater supplies. One research effort supported by the Illinois Pollution Control Board and the Hazardous Waste Research and Information Center will assess the impact of six contaminants through 14 different hydrogeological environments. Another project is determining the effects of past and present oil field brine disposal practices in a pilot study in Clay County. In two service projects in Winnebago County, the impact of sewage sludge on groundwater sources is being evaluated.

- Preliminary studies to assess groundwater quality have been initiated in St. Clair and Madison Counties.

- Suitable sites in McHenry County for a landfill of municipal waste are under investigation. Sensitive areas have been mapped. An initial inventory of landfills in this county and throughout the state has been completed. Some 2,890 disposal sites have been identified. An update of this inventory is now underway using new information from county, regional, and state governments. Emphasis is being placed on identifying sites used for the disposal of hazardous wastes.

- Regulations and regulatory practices governing deep-well injection of hazardous and nonhazardous wastes have been judged to be adequate. They will ensure long-term protection of underground sources of drinking water, human health, and the environment. The existing requirements for siting, design and construction, operation, testing and monitoring of Class I wells were also concluded to be adequate. For certain types of hazardous wastes, deep-well injection is one of the less expensive disposal options. Additional work including modelling of subsurface conditions is underway to investigate the hydraulic effects of deep-well injection of the injection zone and its associated confining layers. The hydrogeology and hydrochemistry of the deepest and oldest reservoir strata, the Mt. Simon sandstone, are being investigated to ensure that Class I disposal wells in this unit are sited where the geologic conditions in the disposal zone and its confining strata will protect all overlying underground sources of drinking water.

- In another study of the physical and chemical interactions of hazardous liquid wastes with rock formations, investigations showed no significant reaction of a highly alkaline water resulting from a pesticide manufacturing process with samples of Mt. Simon sandstone, Potosi Dolomite, or Eau Claire formation, the formations used as disposal zones in Illinois.

- In related studies, dramatic improvement was noted in the quantity and quality of groundwater monitoring at hazardous waste disposal facilities in Illinois over the past 10 years. Additional conclusions and recommendations resulting from this review have been identified.

- The degree of risk of Class V injection wells was also assessed. Heat pump return flow wells have little or no risk of contamination, but those used for storm water runoff, agricultural runoff, and nonhazardous waste have some risk of contamination

- A joint Geological Survey and Water Survey project has outlined a methodological approach for siting a low-level radioactive disposal facility in Illinois based on geologic and hydrologic considerations. Four steps are recognized in a site selection process: (1) regional exclusionary screening based on certain factors, (2) regional directive screening to locate favorable areas, (3) site screening to determine general conditions in a favorable area and possible fatal flaws, and (4) site characterization to describe the site in detail.

- During the year, ISGS staff reported on the hydrogeologic suitability of 79 proposed or existing waste disposal facilities in a number of counties throughout the state.

Illinois Lakes and Rivers

- Record high lake levels, storm impacts, and flooding created a great demand for technical data and services for communities, government bodies, businesses, and property owners along the Lake Michigan shoreline. Consulting help on shore protection was provided to a number of organizations, and Charles Collinson is serving on the Mayor's Chicago Shoreline Protection Commission.

- The monitoring program of the Lake Michigan shoreline was expanded with more frequent flights to examine structural damage and erosion and to record sequential developments. New mapping of bathygeneity and shoreline recession features was instigated along with a new study of littoral drift systems.

- A project for the National Park Service has produced a 157-page geologic reference book and a color brochure about the Ice Age heritage of the Illinois-Michigan Canal National Heritage Corridor.

Hydrogeology

- The ISGS assisted the Governor's Groundwater Protection Task Force in developing comprehensive draft legislation. The legislation has multiple aims: to identify groundwater resources, establish groundwater baseline conditions and assess the degree of contamination, establish a long-term monitoring program, develop a computerized groundwater database, and establish a problem-solving research program for mitigation of contaminated groundwater sources.

- In Mason County, trace levels of herbicides and insecticides have been found in a preliminary study of groundwater. The persistence and fate of pesticides in loessial soils is being studied.

- Groundwater resource studies are being conducted in the Rockford area of Winnebago County; Kankakee and northern Iroquois Counties; and DuPage, Kane, Lake, and McHenry Counties. Information is being developed on the distribution and thickness of shallow groundwater aquifers. Aquifers with large potential groundwater supplies have been located at Aurora, Geneva, and Montgomery with sophisticated geophysical exploration techniques.

- The Survey continued to provide services on groundwater supplies to county soil and water conservation districts, to communities, and to the general public. In one investigation, an ISGS surface electrical resistivity survey, was used to site three observation wells and one test well capable of yielding 200 gallons per minute. Also in support of the Water Use Act of 1983, the Survey evaluated the hydrogeolgic conditions in the vicinity of 62 wells during the year.

Earth Hazards and Engineering Geology

- Slope failures and landslides in Iroquois County, Vermilion County, and Chester are being investigated to determine failure mechanisms and to suggest appropriate remedial action.

- A five-year mine subsidence research program has been initiated to develop guidelines to maximize coal production while minimizing the effects of subsidence on prime farmland. The effort, carried out in cooperation with the University of Illinois and Southern Illinois University, is jointly funded by the State, the U.S. Bureau of Mines, and the Coal Development Board. Work to date includes investigation of floor stability, installation of instrumentation to monitor subsidence, and crop studies over mined-out areas.

- Data from the Mine Subsidence Insurance Program shows that many damage claims are not related to mined-out areas. Rather, the alleged damage appears to be related to swelling soils. This concept has been the basis for a proposal to initiate a new project on problem soils that result in cracked basements and foundations, and, in some cases, structural failure.

GENERAL AND BASIC RESEARCH

- The last in the series of 7.5-minute topographic maps of Illinois has been completed. Complete topographical coverage of the state is now available at this scale. The next cycle of updating is already being planned to allow for the rapid changes in cultural features, so that the topographic maps can be used as accurate base maps for planning and construction purposes as well as for recreational use.

- A 30,000-foot Illinois Basin Ultradeep Drillhole (IBUD) in southernmost Illinois was proposed to DOSECC, the NSF operating arm for the Continental Scientific Drilling Program in the United States. The science plan for this hole was developed in a workshop of more than 120 geoscientists from various parts of the United States and in follow-up discussions with a number of principal investigators. IBUD, to be located at the junction of the Reelfoot Rift System and the Rough Creek Graben, would provide scientific insight on the nature and origin of the initial rift, the underlying basement rocks, and the geological evolution that led to the development of a cratonic basin. Detailing the time-stratigraphy in one of the most completely preserved sections in the mid-continent, along with an analysis of burial and thermal history, would provide a model for crustal evolution for comparison with other mid-continent regions.

- "Build Illinois" funds totaling more than $1.25 million were used to purchase new major pieces of scientific equipment. This landmark acquisition of state-of-the-art instruments enables the Survey to carry out more quantitative geological and geochemical investigations with greater resolution and precision as well as to help attract and retain highly qualified staff and encourage further opportunities for cooperative research programs with other government agencies, institutions, and industry.

- Cooperative geological mapping with the USGS in southern Illinois has led to the publication of three 7.5-minute quadrangles. Work is underway on an additional five quadrangles. The effort is leading to new discoveries of geologic significance, to the detailing of coal and other mineral resources, and to maps useful for both economic and environmental planning purposes.

- Surficial mapping was also carried out in four 7.5-minute quadrangles over Hicks Dome leading to stack-unit maps of the upper 20 feet of section.

- Basic research continued to provide new insights on the geomorphology, stratigraphy, erosion, and sedimentation of river basins; on the development of soil-weathering profiles; on the thermal behavior of near-surface materials; on the ages of samples dated by the ISGS radiocarbon lab; on clay mineralogy as an indicator of weathering; on the alteration of clay minerals by plants, weathering, and soil genesis; on the chronology and drainage history of the Lake Michigan Basin; on correlations of K-bentonite beds of Ordovician age; on the stratigraphy of the oldest sedimentary rocks in Illinois; of the paleontology and palynology of Paleozoic sediments; on basin-wide correlations of coal beds; on structural features present in Illinois; and on the use of computers in ISGS research and service programs.

- As a part of the Survey's basic research efforts, shatter cones were discovered in rock cores from both the Glasford and Des Plaines Disturbances. Shatter cones are evidence of an ultrahigh velocity impact. The shatter cones help support the origin of these "disturbances" as meteoroid impacts.

ADMINISTRATIVE AND SCIENTIFIC SUPPORT SERVICES

Public Relations

- A separate public affairs unit was established in January 1987 to help explain, publicize and promote the research, service activities, programs and events of the Geological Survey.

Publications, Graphics, Photography Unit

- GEONEWS, a new ISGS newsletter, was introduced.

- Output of scientific poster presentations doubled.

- The unit was involved in 133 publication projects.

Information and Technical Services

- The Survey has installed a new telephone system replacing the 46-year-old switchboard that was installed when the Natural Resources Building was built in 1940.

- Well log copying services continue to be popular, but the downturn in the petroleum industry has produced a marked decline in the numbers of copies requested.

- Duplicating services now occupy new space on the South Campus. The unit produced a number of attractive, high-quality color printing jobs last year including GEONEWS, Satellite Image Map flyers, and the new Geologic Quadrangle Map announcement.

Word Processing Center/Technical Records

- This unit handled a variety of assignments from mail distribution to vehicle reservations to typing and word processing.

- The NBI 64 was interlinked for direct transmission of manuscripts to the Allied Linotype typesetter.

Library/Map Room

- Reference questions and circulation of articles increased dramatically this past year.

- Library acquisitions, including those in the map room, also increased significantly.

Human Resource Office

- This office continued to perform vital functions and handled extraordinarily heavy loads in the Survey's personnel evaluation program, in providing training, in recruiting, in counseling staff, and in responding to the public.

Technical Design, Operations, and Maintenance

- Walls, sinks, old fume hoods, plumbing were removed and new walls and utility supply lines were installed to provide five new offices for the SSC geological task force, new space for Geological Records Unit files, and new space for the Computer Research and Services Section.

- Major preparations were completed for the design and installation of major new scientific equipment including an isotopic mass spectrometer, a scanning electron microscope, an X-ray diffractometer, and a GC Mass Spectrometer. Other changes in existing equipment were made to accommodate the new instruments.

- The Unit designed, constructed, and installed such new equipment and facilities as an underwater camera protection device for use in Lake Michigan, a device to speed up slide making, new computer tables, a bulk pack sampler for the X-ray diffraction unit, tensiometer ceramic cups for the compaction clay liner study, a stairway to the attic of the shop and equipment building, and a communication link between the NBI central processing unit and the new typesetter.

- A total of 335 repair, fabrication, maintenance, and moving requests were completed in response to internal work orders.

- The electronics shop processed 168 internal work orders for electrical/electronic installation, maintenance and repair.

Capital Development Board Projects

- Funds have been released and planning and preliminary design work have begun on CDB Project 244-03-003. The project involves the renovation of the Natural Resources Building, the Natural Resources Annex, and Applied Research Building to provide a safety upgrade for designated laboratories and a fire alarm system for the NRB. Three projects have been combined into one:

	Estimated Cost
ISGS Lab Upgrade I	$ 470,000.00
ISGS Lab Upgrade II	316,000.00
NRB Fire/Smoke Alarm System	308,000.00
	$1,094,000.00

Bidding is scheduled for the summer of 1987 with substantial completion targeted for January 1989.

Planning and preliminary design work for the renovation of room 203 Applied Research Building, including the installation of laboratory equipment, is underway with a projected expenditure of $75,000.00. This project is scheduled for completion in the fall of 1987.

EDUCATIONAL EXTENSION UNIT

- Four Geological Science Field trips were held this past year for elementary, high school, and college teachers, students, and the general public. The one-day trips included excursions in the vicinity of Carbondale, Ottawa, Batavia/Fermilab, and Charleston, Illinois. Two special field trips were also conducted to the Zion-Lake Bluff area and in the vicinity of Champaign.

- The Educational Unit continued to respond to inquiries from teachers, students, and interested laymen on the geology of Illinois. Lectures and workshops were provided this past year at Willowbrook, Burr Ridge, and Beardstown on Illinois coal resources and at Urbana and Chicago on satellite image maps. Exhibits and displays were arranged for special events in Mt. Carmel, Zion, Chicago (3 events), and Urbana.

ACTIVITY MEASURES

The activity measures reflect the level of effort of the Illinois Geological Survey's research and service activities and of the staff's substantial efforts to assist the public, industry, agriculture, and government in working towards a sound economy and a healthful environment.

- ISGS scientists reported 118 active state-funded research projects in progress last year. The number of sponsored research projects increased by 15 from 90 in 1985-86 to 105 this year. Approximately 47 percent of all active research projects are funded through contracts and grants. This represents another major increase in contract and grant activity.

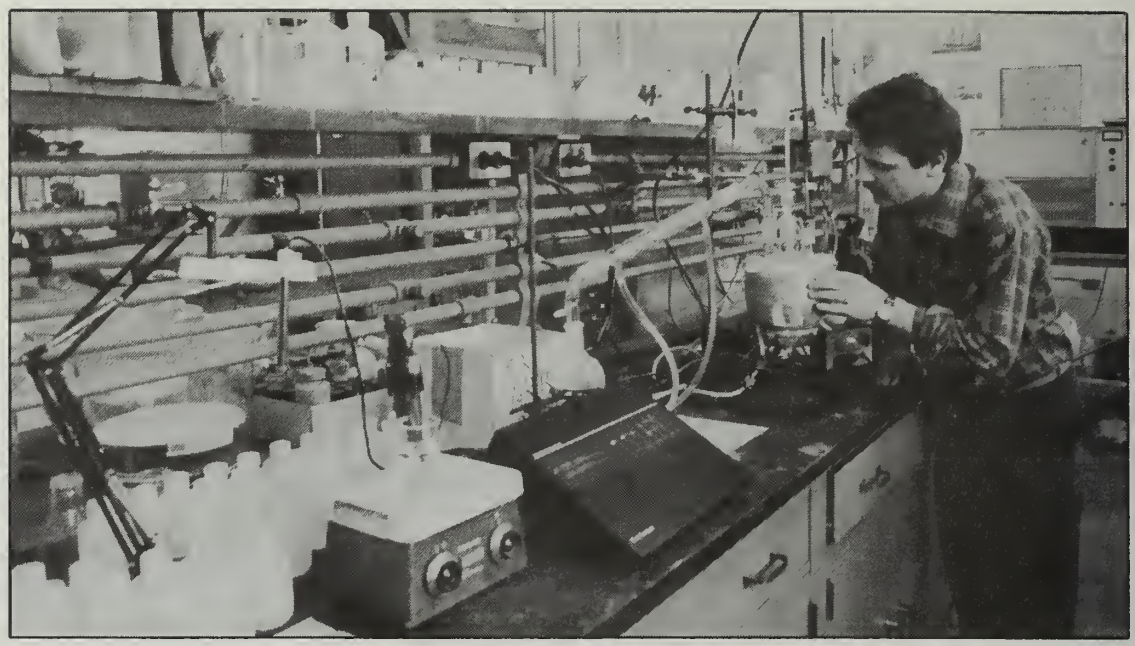
- There were 184 new articles, reports, maps, and abstracts published and 25,552 copies of ISGS publications distributed.

- Survey personnel gave 408 lectures, talks and presentations, contributed to 193 workshops, classes, and seminars, and received 6,860 visitors.

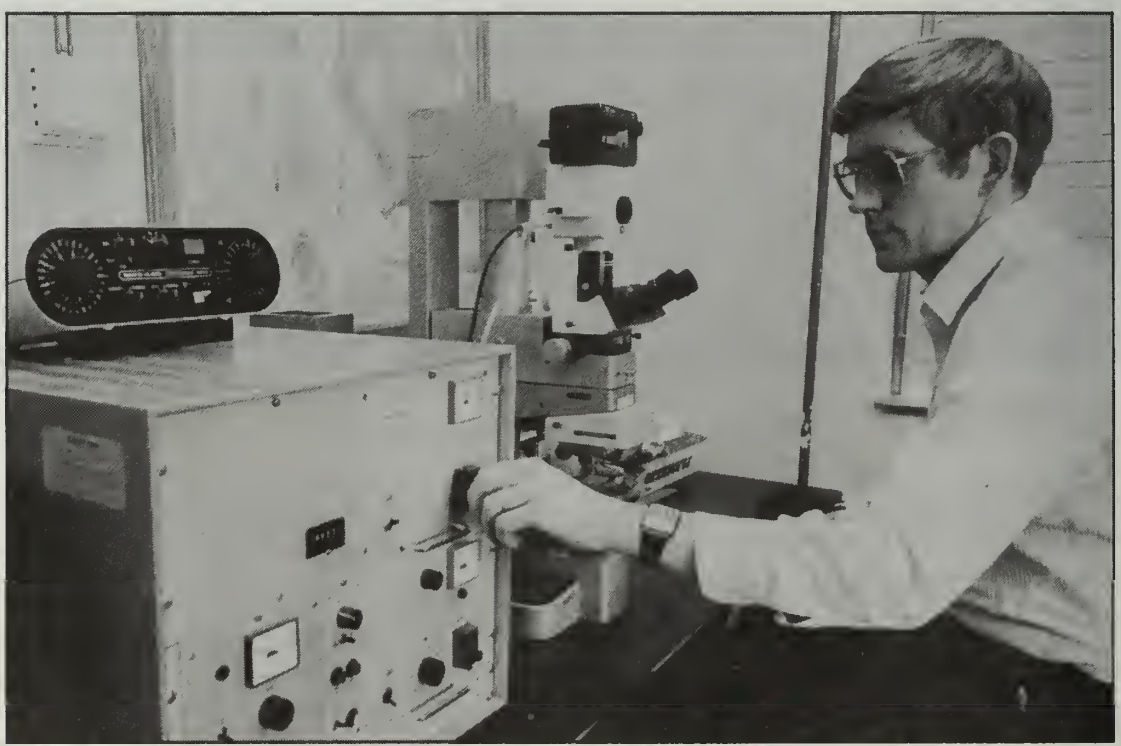
- The Survey responded to more than 15,860 telephone inquiries and 5,807 letter inquiries, resulting in increases of 68 percent and 12 percent, respectively, over the preceding year.

Mineral Resources

Andy Reeves (left), Mike Summers (center), and Richard Read work with the continuous-flow apparatus used for physical cleaning of finely ground coal from the Illinois Basin. The process separates pyrite and ash from the coal.



Ilham Demir checks the coal-water slurry sample as part of a study to determine the effectiveness of water leaching as a method for removing chlorine from Illinois Basin coal.



Brian Trask examines thin-sections of cores with the Leitz polarizing microscope equipped with illuminator and automatic camera. The cores were acquired during drilling for the Cooperative Geologic Mapping Program with the USGS (COGEOMAP) in southern Illinois.

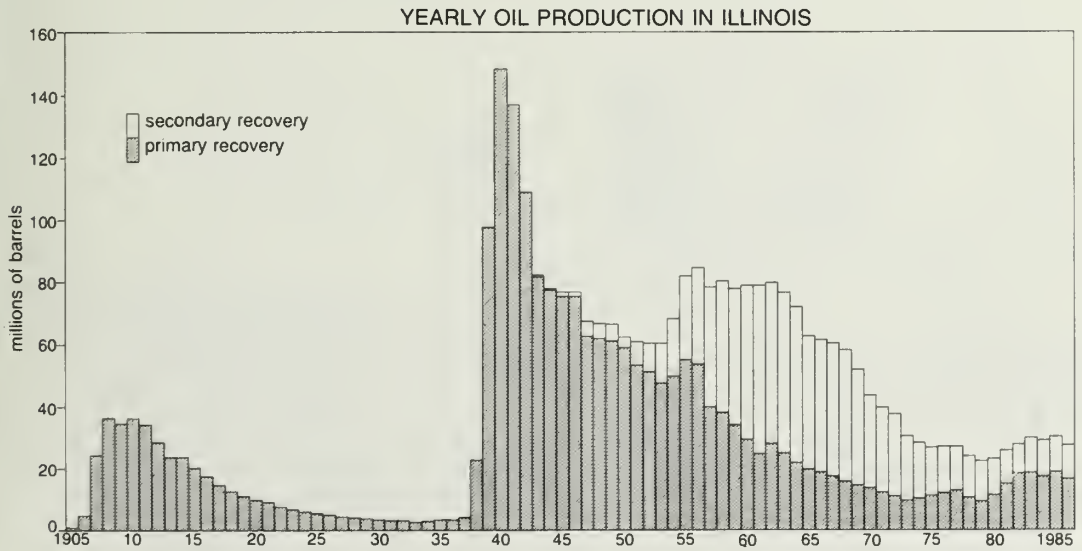
MINERAL RESOURCES

To ensure adequate exploration, wise development, and effective utilization of the state's mineral resources remain the goals of the ISGS mineral research and service programs. Recent acquisitions of data on fuels (coal, oil, and gas), industrial minerals (limestone, dolomite, sand and gravel, fluorite, and metals), and strategic minerals (lead zinc, beryllium, thorium, and rare earth minerals), point to regions where previously unsuspected deposits lie. The long-term prospect is sound investment in extracting, processing, and marketing the state's wealth of mineral reserves.

Survey scientists have intensified their efforts to develop efficient, low-cost methods for removing sulfur from high-sulfur Illinois coal. Ways are also being sought to remove sodium and chlorine that cause corrosion and other problems in boilers. Another imperative for Illinois, given the low level of national effort, is basic and applied research related to coal's minor constituents, which are presently deleterious yet potentially valuable.

Oil and gas production from the Illinois Basin (as from other U.S. basins) is characteristically episodic: a new idea, a new play, a new and deeper field, or a significant advance in the technology for tertiary oil recovery could significantly alter the historical production curve for Illinois. As this episodic history suggests, production in Illinois should again increase significantly.

Sand, gravel, and stone account for more than 88.9 percent of Illinois industrial mineral production. The largest consumer of these materials is the construction industry. As reserves at existing quarries become depleted and urban sprawl encroaches on potential quarry sites in large metropolitan areas, the search for new sources of crushed stone for construction of roads and buildings becomes urgent. Survey scientists are playing a significant role in this search--identifying sources of construction aggregate, evaluating their quality, and investigating the feasibility of underground mining to ensure future supplies.



Mineral production data for 1985 and 1986.

Commodity	Unit	1985 Quantity	1985 Value (thousand $)	1986 Quantity	1986 Value (thousand $)	Percentage of change from 1985 to 1986 Quantity	Percentage of change from 1985 to 1986 Value
MINERAL MATERIALS MINED							
Fuels							
Coal	thousand tons	60,477	1,862,699	62,611	1,847,025[a]	+ 3.5	- 0.8
Crude oil	thousand bbl	30,226	813,093	27,743[a]	399,499[a]	- 8.2	- 50.9
Natural gas	thousand Mcf	1,324	3,668	1,216a	2,821[a]	- 8.2	- 23.1
Industrial and construction materials							
Stone	thousand tons	41,046	164,224	44,002	178,507	+ 7.2	+ 8.7
Sand and gravel	thousand tons	30,656	133,915	32,800	137,500	+ 7.0	+ 2.7
Clays[b]	thousand tons	265	876	271	948	+ 2.3	+ 8.2
Fluorspar	thousand tons	W	W	W	W	+ 18.8	+ 13.2
Tripoli	thousand tons	W	W	W	W	+ 2.6	+ 3.2
Metals							
Lead	tons	W	W	W	W	- 46.4	- 37.7
Zinc	tons	W	W	W	W	+110.6	+ 98.2
Silver	troy ounce	W	W	W	W	--	--
Copper	tons	W	W	--	--	--	--
Other							
Peat	thousand tons	W	W	W	W	+ 12.2	+ 14.2
Gem stones		NA	15	--	15	--	--
Barite, primary	thousand tons	W	W	W	W	--	--
Values that cannot be disclosed (W)		--	33,588		37,089	--	+ 10.4
Total value of mineral materials mined			$3,012,079		$2,603,389		- 13.6

[a] Estimated by ISGS

[b] Excludes fuller's earth; included with value of items indicated by symbol W.

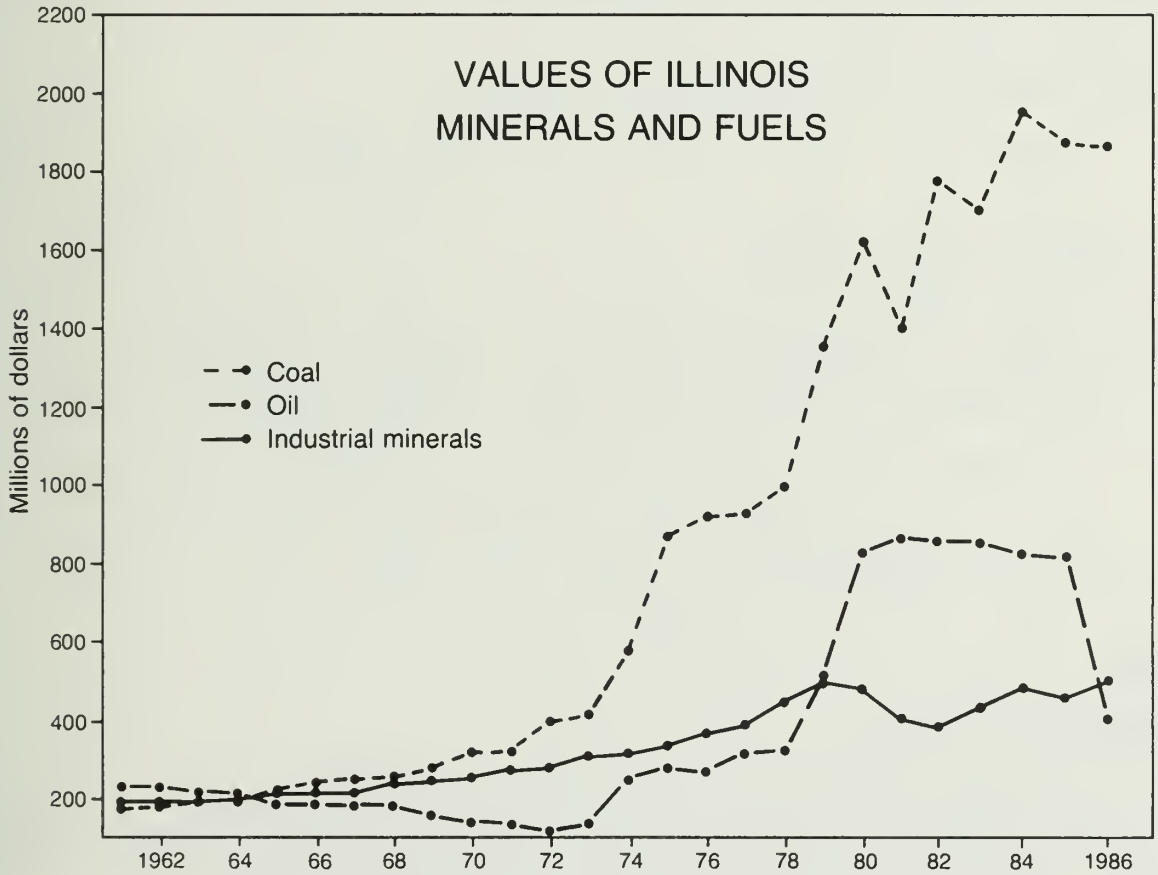
W = Withheld to avoid disclosing individual company confidential data.

ILLINOIS MINERAL INDUSTRY IN 1985 AND 1986

The 1985 mineral production in Illinois was valued at approximately $3.0 billion, a decrease of 4.0 percent from 1984. The total 1986 value of minerals produced in 1986 was about $2.60 billion or about 13.6 percent lower than in 1985. Figure 1 illustrates long-term trends.

In 1985, coal, oil and gas accounted for 98 percent of the total value while stone, sand and gravel, and clays accounted for 10 percent. All other minerals together contributed about 1 percent to the total value of minerals produced in 1985. Coal remained the most important mineral in Illinois with a value of about $1.86 billion of 61.8 percent of the state's total mineral production.

Coal production in 1986 increased 3.5 percent while estimated value remained nearly unchanged from the 1985 level. Oil production declined about 8 percent in 1986 with the estimated value dropping about 50 percent due to the oil price decline.



Selected Mineral-Related Illinois Laws Passed

PA 84-1293 - effective date 8-09-86--amends the oil and gas conservation act, defines "Enhanced Recovery Method," and substitutes "Enhanced Recovery Method" for secondary recovery.

PA 84-1313 - effective date 1-01-87--amends the civil administrative code of Illinois to create a division of coal marketing in the Department of Energy and Natural Resources; it also authorizes the DENR to cooperate with DCCA for the promotion and marketing of Illinois coal both domestically and internationally.

PA 84-1315 - effective date 1-01-87--amends the state occupation and use tax acts, eliminates tax on certain coal exploration and mining equipment and repair and replacement parts for them, and requires that equipment and parts be worth more than $250 to qualify and be manufactured in the United States.

PA 84-1343 - effective date 1-01-87--amends the Revenue Act of 1939, provides for the separate assessment of mineral rights only if such rights have been conveyed to a person who does not own the other rights to the property, and provides that rights to minerals for which there has been issued no extraction permit may not be assessed at more than $35 per acre of property to which the rights relate.

Other Noteworthy Mineral Resource Developments

- Illinois Power Company now burns 100 percent Illinois coal. It replaces the last western coal contracts (12.5%) with new Inland Steel coal from the No. 1 Mine near Sesser, Illinois. The coal will be burned at IP's Wood River power station.

- Illinois Commerce Commission approved a permanent rule for the Illinois Residential Affordable Payment Plan called the "12 percent plan." It prevents utilities from disconnecting services as long as the customers pay at least 12 percent of their monthly income toward utility bills.

- Low interest loans of up to $2.5 million or 25 percent of project cost are available to help finance new or improved facilities that burn Illinois coal. The loans are part of the Illinois Coal Utilization Program administered by the DENR.

COAL

Research and Service

Two-thirds of Illinois is underlain by coal-bearing strata. Industry, government, and private citizens depend upon the Geological Survey for authoritative and current information on the state's vast store of coal resources. Survey researchers identify, quantify, and characterize the state's coal and study the rock materials associated with coal seams to determine their influence on coal quality, minability, and land subsidence after mining. A major

effort is directed towards understanding the nature of the occurrence of sulfur and chlorine in our coals and removing these deleterious elements economically. Many Survey projects are supported by the Center for Research on Sulfur in Coal (CRSC).

Activities of the Coal Mining Industry (Damberger, Morgan, and Bhagwat). In October 1986, the Illinois Mining Institute held a widely attended forum on the "Future Economic Health of Illinois Coal Markets" which brought together leaders in coal marketing, purchasing, and market analysis. Discussions focussed on recognizable trends towards short-term contracts, significantly increased use of the spot market, and the treatment of coal as a commodity. During the meeting, Inland Steel Coal Company announced the sale of its two Illinois mines to Consolidation Coal Company. The sale continued the trend of steel companies to divest coal reserves and coal mines in recent years.

The total number of coal mines operating in Illinois declined to 51 at the end of 1986 from 52 in December 1985, although the state's coal production rose to about 63 million tons from last year's 61 million tons. In Douglas County, immediately to the north, Zeigler Coal Company has closed its Mine No. 5 due to difficulties in marketing the coal produced by the mine. Sahara Coal Company closed its No. 7 Mine in Saline County. Freeman-United closed its Mt. Vernon office, and Zeigler closed its Chicago office; both reduced staff at the same time. Arch Mineral Corporation purchased the Leahy Mine (Perry County) from AMAX Company; the mine is now named the Denmark Mine and is operated by Pipestone Creek Company, a subsidiary of Arch Mineral. Only one mine is currently under construction, near Oakland, in northeastern Coles County of east-central Illinois.

Coal exploration reached a new low point. Thirteen companies filed 1,380 plugging affidavits for coal wells (compared to 1,868 last year), representing a 26 percent decrease. Only about 58 holes were far enough from existing mines to be considered exploration drillholes (compared to 118 last year). All other holes were related mostly to active surface mines. Companies known to be actively drilling include Amax Coal, Cononie Construction, Consolidation Coal, Exxon Coal and Minerals, Freeman United Coal Mining, John Mathes and Associates, Monterey Coal, Old Ben, Peabody, Shot Point Services, Tower Fuel, and Zeigler Coal.

Future of Illinois Basin Coal: 1994 and Beyond (Bhagwat). A larger regional study of high-sulfur coal markets reported under the Mineral Economics section of this report led to a close-up view of Illinois Basin coal in Illinois, Indiana, and western Kentucky. With very little low-sulfur reserves available, the Illinois Basin has suffered more under the recorded widespread market stagnation for coal than did other states such as eastern Kentucky and West Virginia. The problems of other high-sulfur states also apply to Illinois Basin. Illinois Basin coal faces tough price competition from eastern, western, and imported low-sulfur coals because its markets are closer to low-sulfur western coals and because mining costs are relatively high. The detailed study of the 17-state market area for Illinois Basin coal reveals that 75 percent of the demand growth for coal in the 1975-85 period has been captured by western coal on the basis of its lower price and lower sulfur content. The study concludes that under current environmental laws, sales of

Illinois Basin coal will remain essentially unchanged until 1994 and rise only slightly by 2000. Sales would decline 30 percent by 1994 and 60 percent by 2000 if the acid rain law is passed and implemented, unless measures to reduce costs are devised and successfully applied. The potential job losses could amount to 5,400 in 1994 and 11,000 in 2000. The study shows that while the problems of Illinois Basin coal are shared by other high-sulfur coal states, these problems are more serious and threatening to the Illinois Basin coal industry. Only concerted efforts at improving mine productivity and reducing sulfur content will save jobs.

Coal Resources and Geology

Coal Exploration Records (Morgan). During this report period Paul Farmer gave the Coal Section all of his Mobile drilling data. This includes 138 geophysical records from Clinton, De Witt, Douglas, Effingham, Jasper, Lawrence, Logan, Moultrie, and Washington Counties and 536 drillers logs from seven counties in Indiana. Also six geophysical records were added to our confidential files from Hydrocarbon Survey. Coastal States Energy gave us core descriptions of 18 coal test holes in Jasper County and the entire cores of 14 holes. This data is not confidential and will be placed in our public files. More than 600 drillhole records from Amax, Consolidation Coal, and Peabody were released from the confidential to ISGS public files.

A Method for Measuring Coal Seam Thickness from Old Electrical Logs (Berggren). "Old" electrical logs are records of oil and gas well surveys made with lateral and normal electrode devices, mostly in the 1940s and 50s. The 61,128 old electrical logs in the Survey's current Basic Well Data provide valuable information about coal resources. Usually the depth and extent of coal seams can be readily determined from these rocks, but measuring the thickness of coal seams and other thin resistive beds (less than 10 ft thick) is difficult because of the nature of the logging devices, the preferred log scales, the well surveying procedures, and geologic factors that affect log quality.

Coal Resources of the Dekoven and Davis Coals in Southeastern Illinois (Jacobson). Data on the coal resources of the Dekoven and Davis Coals have been collected for all of Gallatin and about half of Saline County, but data for another five counties remain to be collected. One cross section has been assembled for the study area.

Geology of Herrin (No. 6) Coal in Central Illinois (Nelson). Coal with a low-to-moderate sulfur content has been preferentially mined in Illinois for many years and interest in it continues to be high. The only new mine currently under construction (in northern Coles County) is to produce coal of a moderate sulfur content (about 1.5% S). The Hornsby area is a relatively untapped low-to-moderate-sulfur area located in Christian, Macoupin, Montgomery, and Sangamon Counties of central Illinois; it contains 1.17 billion tons of coal resources that should have less than about 2.5 percent sulfur and possibly as little as 1 percent. Circular 540, "The Hornsby Deposit of Low-Sulfur Coal, West-Central Illinois," should be available for distribution in July 1987.

Coal Resources Information System (C. Treworgy and Bargh). Published coal resource data are being edited and loaded into a computer system for the purpose of managing and analyzing the coal resource data. Programming and data entry completed this year provide the capability to produce generalized maps and tonnage reports for all deep-minable resources. Data on the depth, thickness, sulfur, chlorine, moisture content, and proximity to areas densely drilled for oil or surface features such as cities, interstate highways, and public lands are included. These data may be combined with other information from ENR's large collection of digital maps to produce maps showing the relation of coal resources to features that may promote or restrict mining operations. Work is currently underway to encode more detailed resource information as well as parameters including coal quality, roof stability, geologic hazards, landcover, and infrastructure. This system will improve the Survey's capability to provide industry and government with resource information that will promote both safe and environmentally sound economic development.

Clastic Infilling of a Lacustrine Basin--A New Feature in the Pennsylvanian of the Illinois Basin (J. Treworgy and C. Treworgy). A large wedge of shale, siltstone, and sandstone overlying the Herrin (No. 6) Coal Member in east-central Illinois and west-central Indiana is a sedimentary deposit unlike any previously described for the Pennsylvanian in the Illinois Basin area. Lithologic and faunal characteristics and vertical and lateral (facies) relations of these rocks relative to adjacent sediments indicate that a lacustrine basin existed within the Herrin Coal swamp and was filled with deltaic sediments. The Herrin Coal, although thin in places, may be relatively low in sulfur throughout the 5,000-square-kilometer area overlain by the clastic wedge as indicated by a few reports of low-sulfur Herrin Coal in the area.

Clay Minerals Associated with the Pennsylvanian Strata of Illinois (Hughes, Moore, Warren, DeMaris, and White). This project is designed to investigate the origin of the complex suite of minerals that occur in the Pennsylvanian strata in Illinois. Research has shown that, while sediments were derived from highland areas to the north and east, kaolinite and expandable clay minerals were formed within the Illinois Basin.

Coal Mining Geology

Coal Stratigraphic Information System (C. Treworgy, Bargh, and Morgan). Development of this computer-based system for managing coal stratigraphic data from mines, outcrops, and drillholes continues. At the end of 1987, the system contained data on more than 10,000 observation points from 45 counties, an increase from 2,500 points in 24 counties at the end of last reporting year. Most points are descriptions of selected intervals of drillholes. Funding was received from the USGS to support the correlation and encoding of about 400 complete drillholes this year. Computer programs have been written to allow geologists to easily query the system (e.g., "What data are available on coals in Bond County that are at least 4 feet thick and less than 300 feet deep?") and obtain printed reports on selected data points. Feedback from users is being used to refine program options and user manuals with the goal of making the system available to the public sometime in 1987.

Coal Mine Information System (C. Treworgy, Bargh, Morgan, and Danner). The initial phase of development of the computerized coal mine information system was completed during the year with the encoding of all mine outlines as they existed in January 1980 (the same date as the paper maps currently distributed by the Survey). Maps are now being obtained from mining companies and are being digitized to update all active mines to January 1987. A procedure was developed to store documentation for the outlines (source, scale, date) as part of the database. By late spring all new mined-out area maps and accompanying tabular reports will be produced by this computer system, enabling the Survey to provide users with more timely and complete mine information.

Composition and Quality of Coal

Characterization of Samples in the Illinois Coal Sample Program (Harvey, Dieter, and Steele). This project, initiated September 1985 and completed August 1986, established a computer database of chemical, petrographic, and mineralogic properties of samples in the Illinois Basin Coal Sample Program. Inertinite contents range from 4 to 10 percent among the 5 samples; arsenic, germanium, and lead are relatively abundant in sample 2. The database also includes the name, address, and short abstract or objectives of the projects being carried out by all researchers who are using samples from the Illinois Basin Coal Sample Program. To date, 55 researchers are working on the samples. This database serves to promote cooperation among all persons doing research on Illinois coal.

Information System on Illinois Coal III: Bibliography of CRSC Projects and Publications (Trask and Harvey). The Illinois Coal Research Board, through CRSC, provided funds to establish a computerized bibliography of CRSC projects and resulting publications. The bibliography will be accessible by remote terminals, permitting CRSC-sponsored researchers and others to search the bibliography.

Mineralogical and Petrographic Properties: FY86 (Harvey, C. Treworgy, Dieter, and Steele). This project, supported by the USGS, enabled us to greatly improve the usefulness of the ISGS computerized data on coal quality, which include analytical results of standard chemical, minor and trace elements, mineralogical, and petrographical data on samples of Illinois coal. A comprehensive database for these properties was designed on our Prime computer, using INFO software. A large file of minor and trace-element data was transferred from the University's Cyber computer to the Prime. Sixteen channel samples from eight active mines that had not previously been sampled were collected and analyzed. The samples were analyzed for chemical, petrographical, and mineralogical compositions, and these data were added to the database. The USGS will be provided with a magnetic tape containing standard analyses and trace element data from abandoned mines. The ISGS data set will become part of a national database, the National Coal Resources Data System (NCRDS).

Stratigraphic and Petrographic Data: FY87 (Harvey, C. Treworgy, and Dieter). The USGS approved a proposal to compile stratigraphic and petrographic data on coal members at some 2,900 drillhole locations. Microscopic analysis will be conducted on 150 channel samples that were collected and prepared previously.

Mineral Matter in Illinois Coals (Harvey and Lowry). The coal used to generate steam at electric power plants contains mineral impurities that generally cause problems and adds considerably to the costs of plant operation. Designers of steam plants and engineers who evaluate various coal-cleaning processes need data on the abundance and types of minerals in coals. A continuing project at the ISGS continues to focus on mineral analyses of Illinois coal. During 1986, 154 samples were subjected to low-temperature ashing, providing the best measure of the total mineral-matter content of a sample and freeing enough mineral sample for subsequent X-ray and microscopic analyses to quantitatively determine the mineral composition of the original coal. During the past year, 91 samples were analyzed for mineralogical composition.

Sodium, Chlorine, and Sulfur in Illinois Coals: Distribution in Coal Lithotypes, Removal by Physical Cleaning, and Behavior During Combustion (C.-L. Chou, Demir, Phillips, Cahill, Chaven, and Sotomayor). Continued funding for this project has been provided by the Illinois Coal Development Board through the Center for Research on Sulfur in Coal. The goals are (1) to obtain a clear understanding of the spatial distribution and chemical forms of detrimental impurities in coal, and (2) to develop technical knowledge that can be used effectively to increase the marketability of Illinois coal. During the past year, hand-picked coal lithotypes were analyzed for ash, sodium, chlorine, sulfur, and trace elements. The results showed that chlorine is concentrated in the organic portion of coal and most likely to be located in micropores. Water leaching was the most effective and practical technique for removing chlorine from coal. Leachabilities of sodium and chlorine varied systematically with lithotypes due to variable pore sizes of lithotypes. To improve physical cleaning techniques, researchers investigated changes in surface properties of coal particles during coal cleaning. Samples of feed coal, fly ash, and boiler slags received from power plants in Illinois were analyzed for mineralogical and chemical compositions for a better understanding of the effects of mineral matter in coal on boiler fouling and corrosion.

Geochemistry of Bituminous Coals of Pennsylvanian Age in the Illinois Basin (C.-L. Chou). Abundances of many trace elements are related to mineral impurities (pyrite, clay minerals, calcite, sphalerite, and quartz). Geochemical characteristics of the Springfield and Herrin Coals were reviewed based on multivariate statistical analysis of existing data sets. Special emphasis has been given to factors that control the variation of sulfur, sodium, chlorine, and trace elements. The sulfur contents show a bimodal distribution and thus may be classified into two groups: low-to-medium-sulfur coal with 0.8 to 2.9 percent total sulfur, and high-sulfur coal with 3 to 8.4 percent total sulfur. The two groups of coal differ in their stratigraphic relationship, pyrite content, abundances of some trace elements, and sulfur isotopic compositions. These relative abundances can be explained by marine transgression that brought abundant sulfate ions and trace elements into the peat, which subsequently transformed into high-sulfur coal. In low-sulfur coal areas, the marine influence was minimal because the peat was covered by thick nonmarine sediments.

Removal of Ash, Sodium, Chlorine, and Sulfur from Illinois Coals by Concentrating Table, Jig, and Froth Flotation Techniques (Demir, Winston, and C.-L. Chou). Experiments conducted to determine the removability of ash, sodium, chlorine, and sulfur from Illinois coals under controlled laboratory

conditions showed that the concentrating table, jigging, and froth flotation techniques remove differing amounts of these contaminants. Because of the different modes of occurrence of ash, sodium, and sulfur, these four impurities were more effectively reduced than chlorine from Illinois coal. Most sodium in coal occurs in the clay minerals, while the remaining sodium is dissolved in pore water. Sodium is removed with clay minerals during the cleaning processes, which separate mineral and coal particles according to their densities. In contrast, most chlorine is adsorbed on the surface of organic matter located in micropores. Thus, water leaching of relatively large coal particles at room temperature can only remove a small portion of chlorine from coal. Pyritic sulfur can be removed by using these physical cleaning techniques if most pyrite particles are detached from coal particles during crushing and grinding.

Surface Charge of Coal in Relation to Coal Cleaning (Demir, C.-L. Chou, Rapp, and Read). Electrostatic charge on coal particles in solutions affects flotation recovery of coal during aggregate flotation and froth flotation processes. Adsorption of ionic species by coal is also affected by the surface charge; the surface charge on coal particles must be monitored and altered, if necessary, using surfactants to increase the efficiency of these surface-dependent coal-cleaning processes. As part of two projects funded by the Illinois Coal Development Board, researchers have measured the surface charge for 13 coal samples suspended in water with and without surfactants added, as a function of pH. The results--which have important implications for fine coal cleaning--suggest that the surface of fresh coal samples is positively charged under natural pH conditions and thus capable of adsorbing significant amounts of Cl^- (chlorine with a negative charge).

Coal Analysis

Techniques for Determination of Ionic Species in Coal and Coal Leachates by Ion Chromatography (Demir, Chaven, and C.-L. Chou). The ion chromatograph, which was set up originally for analyzing coal and coal leachates for the chlorine-in-coal project, has been upgraded. With funds from the Illinois Coal Development Board, an integrator, a cation column, and other parts were added. The new capabilities of the equipment make it possible to analyze coal and coal leachates accurately and quickly for most water-soluble anions and cations. Thus, the effect of leachate chemistry on the coal-washing processes can be effectively investigated.

Chemical Methods Development (Chaven and Coal Laboratory staff). The ISGS Coal Analysis Laboratory is among the most modern laboratories of its kind primarily due to Coal Development Board Awards through the Center for Research on Sulfur in Coal (CRSC), to "Build Illinois" funds, and to equipment donations.

The installation of a LECO MAC-400 Proximate Analyzer has increased our capacity to perform moisture, ash, and volatile matter determinations in coal to about 38 samples per day. The results have been more consistent and reliable than equivalent data produced by standard ASTM procedures. The new LECO CHN-600 Ultimate Analyzer permits carbon, hydrogen, and nitrogen determinations to be completed in about 5 minutes, using relatively large samples--an important factor in obtaining representative coal analyses.

A Shimadzo UV-VIS Spectrophotometer has been installed for use in the development of a new analysis scheme for forms on sulfur in coal-derived products such as chars, which contain sulfides and elemental sulfur, as well as the pyritic and organic forms recognized as existing in raw coal. A Perkin-Elmer Atomic Absorption Spectrophotometer has also been installed to determine pyritic iron, replacing the old titrimetric method. The Dionex Ion Chromatograph 2000i has been updated to increase capability in analyzing both cations and anions: the cation column will be used for alkaline and alkaline earth metals in coal leachate studies; the anion column will be used to develop a method for sulfate determination in a high chloride matrix. This method will replace the gravimetric procedure currently used. A Shimadzu integrator will be used with both the Dionex Ion Chromatograph and Carlo Erba CHN analyzer; the latter instrument is used for CHN analyses in very small samples (1 to 2 mg).

Application of Thermal Analysis in Coal Research (DeBarr, Moran, Mirza, Rostam-Abadi, and Kruse). The Thermal Analysis Laboratory (ThAL) was established at the ISGS in 1983 to obtain data useful for process-development research. Several computerized instruments provide analytical capabilities for thermogravimetry (TG), derivative thermogravimetry (DTG), differential and thermal analysis (DTA), differential scanning calorimetry (DSC) and thermomechanical analysis (TMA). Current activities aid ISGS engineers and scientists in research related to pyrolysis technology, agglomeration tendencies of caking coals, reactivity of coal-derived solid fuels, hot gas desulfurization, and use of calcium-based sorbents to control sulfur-dioxide emissions from combustion gases.

In combustion research, TG and DTG techniques are used to determine combustion properties of desulfurized and partially devolatilized coal-derived fuels. Methods are being developed to correlate the combustion reactivities determined by TG with data obtained from fluidized-bed combustion tests. A novel technique using pressure differential-scanning caloriometry is being developed to determine the ignition characteristics of coal chars. Also, TG was used to obtain SO_2 sorption capacity and reactivity of treated limestone under conditions simulating a flue-gas environment.

The effectiveness of spent oil shale (eastern and western) in removing hydrogen sulfur from a stream of gas at high temperatures was evaluated by a thermogravimetric method. Rate data for sulfidation were obtained on spent oil shales prepared under the various conditions existing in typical hot-gas desulfurization processes.

Determination of Forms of Sulfur: Fractionation Scheme for Coal Pyrolysis Products (Chaven, Kuykendall, and Kohlenberger). Accurate determination of the varieties of sulfur in thermally and chemically altered coals is vital for selection of process changes and desulfurization strategies.

At least six forms of sulfur cause concern: (1) elemental sulfur, (2) solvent-soluble organic sulfur, (3) acid volatile sulfur (pyrrhotite), (4) acid soluble sulfur (sulfate), (5) pyritic sulfur, and (6) residual sulfur (organic). A method for determining elemental sulfur was developed based on the absorption spectra in the region of 250 to 350 nm; it is being evaluated for interferences from other solvent-soluble sulfur compounds present in coal. Other methods of sulfur determination are also being investigated,

including the use of fast-column ion chromatography for sulfate and the specific ion electrode for sulfide. Various projects supplied feed coals and pyrolysis products for study of this methodology--a continuing effort at ISGS in support of the coal-desulfurization program.

Neutron Activation Analysis in Coal and Petroleum Research (C.-L. Chou). A bibliographic review with 55 references was completed for the Workshop on Applications of Neutron Activation Analysis in the Earth Sciences held in Taipai, Taiwan, during August 1986. Topics include determination of major and trace elements in coal, geochemistry of trace elements in coal, chemistry of coal utilization, and trace elements in crude oils.

Computer Applications at Applied Research Laboratory (DeBarr, Stephenson, Rostam-Abadi, Read, Crawford, and Chaven). The computer facilities have been upgraded in the main office as well as the fluidized-bed, thermal-analysis, and coal-analysis laboratories. In the fluidized-bed laboratory, two temperature controllers now interface with a PC; a second PC has been added to interface with a gas chromatograph. As part of the upgrade for the existing PCs in the thermal and coal analysis laboratory, software was custom written and implemented to improve efficiency in producing reports for the coal-analysis laboratory.

Applied Research Laboratory Machine Shop (J. Cooper). Basic installation of equipment and followthrough maintenance by the Shop were provided for several contract projects: the design and construction of a computer cabinet and instrument panel for a fluidized-bed unit, remodeling of the lattice work to secure a second fluidized-bed unit, installation of a hood over a gas chromatograph instrument, installation of new glassware on the TGA unit, and the building of an aluminum sample box to accomodate samples for the TGA unit.

New analytical instruments were installed in the Coal Laboratory. Electrical lines were run to each instrument, and multiple gas and air lines were installed. The Carlo Erba sulfur analyzer was reworked and installed into the new system. A new hood was built and installed over the atomic absorption unit. New equipment was designed, built, and installed on the reactor for an EPRI-sponsored coal desulfurization project.

Barrel modifications were made prior to processing the new Indiana coal samples for the Illinois Coal Sample Program. Shelving for storage of the barrels is being built.

Coal Desulfurization and Coal Cleaning

The ISGS Aggregate Flotation Fine-Coal-Cleaning Process (Read, Ehrlinger, DeMaris, Rapp, Camp, Summers, and Ruch; FitzPatrick, Northwestern University; Meyers, Southern Illinois University). During the last three years, with partial funding from the Illinois Coal Development Board, the Minerals Engineering Section has been working with Northwestern and Southern Illinois Universities to develop a fine (less than 400 mesh) coal-cleaning process. The program has required extensive ISGS chemical, petrographic, and mineralogical research to delineate process parameters.

The Aggregate Flotation (AF) Fine-Coal-Cleaning Process is still undergoing extensive testing, but tests at the batch level (100 g), continuous-

flow, small pilot plant (30 lbs/hr), and small plant scale (1/3 ton/hr) all confirm its advantages and superior performance over conventional froth flotation for the removal of pyritic sulfur and ash from Illinois coal.

- The AF process is applicable for benefacting ultrafine run of the mine, deslimed, or tabled feedstocks: our tests yield a product that exceeds 80 percent BTU recovery while rejecting more than 80 percent of the ash and pyrite. Cooperative efforts with Northwestern University and Inland Steel Company have resulted in achieving a compliance coal (<1.2 lbs $SO_2/10^6$ BTU) from 1.3 percent sulfur "met grade" coal. This was accomplished in a pilot plant cell.

- Conventional froth flotation equipment may be utilized in the AF process: the unique character of fine bubbles required to enhance recovery of ultrafine coal is controlled by specific reagents and is not equipment-dependent. Cooperative work with SIU has produced promising proprietary compounds that exhibit significant reduction of dosages required to produce good BTU recovery (compared to reagents commonly used).

- AF has been successful in recovering saleable coal products from waste streams and gob: preliminary results on both feeds show high BTU recovery (80%) with good ash rejection. A pre-AF step, such as tabling, may be required for gob beneficiation.

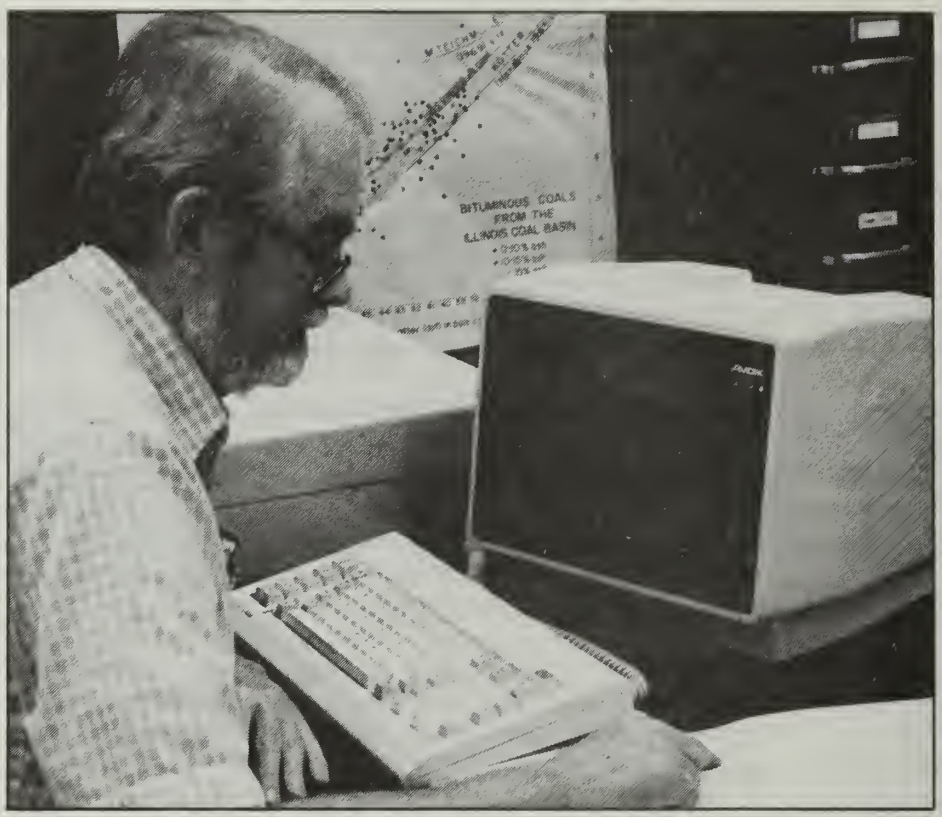
- Preliminary continuous-flow experiments (10 to 30 lbs/hr) closely parallel extensive batch tests for a tabled Springfield coal: batch testing showed that for recoveries of approximately 90 percent of this coal's heating value, corresponding ash and pyrite rejection ran 50 to 60 percent and 35 to 45 percent, respectively. Preliminary continuous-flow runs yielded 50 to 55 percent ash rejection and 40 to 45 percent pyrite rejection at the 90 percent BTU recovery level.

- Potentially hazardous trace elements and chlorine are more effectively removed by AF than conventional froth flotation: these elements tend to remain in the waste tailings. Chlorine is effectively removed in the wet grinding steps.

- Coal petrography was a useful tool for accessing coal cleanability: trends in mean grain diameter and "pyrite cleanability indices" have clarified changes occurring in both grinding and cleaned sample sets.

- X-ray diffraction has been successfully employed for determining the relative ease of removal of sulfur and ash-forming minerals in feeds, concentrates, and tailings generated by the AF process.

- Prospects for future development and application of the AF process are excellent: present efforts are concentrating upon further reagent optimization, refining ancillary treatments, and planning for commercial testing. This process has the potential to be readily utilized in existing plant equipment, and it could become commercial within a relatively short time. Coal cleaned by this process has a ready-made market in power plants using advanced technologies such as stack-gas scrubbers and limestone rejection to reduce sulfur emissions.



Dick Harvey examines a printout from one of the coal databases he was instrumental in developing to provide access to information on chemical, petrographic, and mineralogic properties of Illinois Basin Coal.

Richard Shiley, co-investigator of the carbon monoxide-ethanol coal desulfurization project, assembles the connection between the autoclave and the gas chromatograph, which samples the gas evolving from reactions occurring in the autoclave.

Illinois Basin coal cleaned by conventional methods is still considered to contain too much sulfur, causing problems with corrosion, excessive wastes, reagent costs, and downtime.

Cooperative Reagent Study for the Aggregate Flotation Process (Read, Camp, and Ruch; C. Meyers, Southern Illinois University). In a concerted effort to find better reagents for use in the Aggregate Flotation Fine-Coal Cleaning process, ISGS researchers are systematically testing and evaluating specific compounds synthesized by C. Meyers of the SIU Chemistry Department. Structure/property correlations related to flotation of ultrafine coal have been obtained both for commercially available and newly synthesized compounds.

Tests on the Springfield (No. 5) Coal (hva) with commercial reagents indicated that chain length, total carbon, and molecular structure were most influential on dosage/recovery behavior. One of the synthesized reagents was the most effective when compared to all other commercial compounds or frothing alcohols. Significant reductions in dosage and increased BTU recovery were observed with this new reagent; in some instances dosage was reduced by a factor of two or more. Moreover, mixing the synthesized compounds with alcohols produced a synergistic effect. Lower dosages of each component in the mixture were used to produce higher BTU recoveries with increased ash and pyritic sulfur rejection.

For the Colchester (No. 2) Coal (hvc), newly synthesized compounds again proved to be the most effective. Significant reductions in dosage relative to BTU recovery were also observed, by as much as a factor of three or more, compared to commercial compounds. Compared to the alcohol-based frother MIBC, the synthesized reagent was seven times more effective. It may be that optimum structure/performance ratios for this new class of reagents is related to the rank of the coal. This aspect, however, requires further evaluation.

Ultrafine Coal Cleaning Via Explosive Shattering and Aggregate Flotation Processes (Ruch, Read, DeMaris, Rapp, Chaven, Summers, and Sresty). ISGS researchers evaluated an ultrafine coal-cleaning technique that combines rapid thermal-chemical comminution and efficient physical separation of coal mineral matter. The Survey's Aggregate Flotation (AF) process, developed for fine-coal cleaning, was used to treat the product obtained from IITRI's Explosive Shattering (ES) process. ES involves application of high pressure and temperature followed by rapid adiabatic expansion that produces an explosive effect and breaks the coal macerals into very small particles (<10 microns). the AF cleaning process, which is used to selectively float the ultrafine coal, is based on preconditioning coal with surfactants, then adding a collector: the result is lightweight, coal-air aggregates.

The combined approach should significantly reduce ash and pyrite levels to a greater extent than use of AF alone. That is, the extensive comminution created by ES would liberate pyrite and ash particles to a greater degree than attrition by grinding only.

Unfortunately, attempts at combining ES and AF have been unsuccessful in demonstrating any significant improvement in mineral matter removal. The reason is believed to be the existence of volatile organic compounds that are produced during the ES process and that coat the coal particles and render them hydrophobic. This minimizes any separation based on hydrophobic/hydro-

philic particle differences. Extensive petrographic, thermal, and chemical characterizations have been made in attempts to understand this limitation, but it has been concluded that attrition (Perl ball mill) grinding is still the preferred method for preparation of coal needed in ultrafine physical cleaning.

Characterization of ISGS Aggregate Flotation Feed and Product Materials (DeMaris, Harvey, Hughes, Miner, and Warren). Petrographic examination of feed coal, cleaned products, and refuse samples from aggregate flotation batch and continuous runs have continued to provide useful information on changes in size and maceral association of pyrite grains in those samples. A wide variety of samples, including cleaned products made from coal preparation plant waste materials, have been examined under the microscope for their pyrite grain size and maceral association. The pyrite cleanability index (PCI), calculated from the size and association data, is feed-size dependent but useful for comparisons among standardized sets of samples. Improved methods to evaluate cleanability on very low pyrite samples are under development.

Enhancement of Sulfur Dioxide Sorption Capability and Reactivity of Lime/Limestone (Rostam-Abadi, Moran, Harvey, and R. Frost). An emerging technology for direct capture of sulfur dioxide from coal combustion is in-furnace sorbent injection, where dry, pulverized calcium-based material (such as limestone or hydrated lime) is injected directly into the furnace cavity of an existing coal-fired boiler. The reactions of interest are decomposition of the sorbent to lime, which reacts with sulfur dioxide to form calcium sulfate. However, recent studies showed that under the conditions existing in utility furnaces, only 20 to 50 percent of the calcium is utilized during the desulfurization. Therefore, methods to improve calcium utilization need to be developed to reduce in-furnace injection operating costs.

This project funded by Illinois Coal Industry Committee is an investigation of the possibility of improving the sulfur-dioxide sorption of limestone by three hydration methods: (1) lime was hydrated with alcohol-water solutions; (2) calcined limestone was reacted with water at pressures and temperatures up to and exceeding super-critical conditions, and the hydrated lime produced was ejected to atmospheric conditions (explosive shattering ores); and (3) lime was hydrated with steam. Sulfur-dioxide sorption reactivities were measured at 850°C by thermogravimetry. Surface areas of selected products were determined by the BET(N_2) technique.

For limes hydrated with methanol-water solution, sorption capacities were equal to or greater than commercially prepared pressure-hydrated limes. Thus, costs associated with pressure hydration could be eliminated by hydration with methanol-water solutions at atmospheric pressure. Other conclusions drawn were

- reactivities of the samples tested showed the following trend: ethanol-water hydration = methanol-water hydration > pressure hydration > steam hydration = hydration with water > lime.
- stream hydration improved calcium utilization in lime.
- calcium conversions exceeding 93 percent were obtained; a linear relationship was found between calcium utilization and surface area of the hydrates.

Low-Temperature Charring (Stephenson, Rostam-Abadi, Kruse, Williams, Ellis, Moran, Liu, Hackley, Hawk, and Sprague). Partially funded by the ICDB, this project continues to focus on the production of a low-sulfur char from high-sulfur Illinois coals. The processing involves pyrolysis (thermal treatment in the absence of air) followed by hydrodesulfurization of the char.

Research during the past year showed that hydrodesulfurization of chars can produce fuels of less than one percent sulfur from some Illinois coals (see table 1). The extent of hydrodesulfurization was highest for preoxidized chars, although desulfurization was also considerable for nonoxidized chars. Kinetic data were also obtained and revealed that the rate of sulfur removal was constant for about 60 minutes of treatment time. Increasing the flow rate was quite beneficial in increasing the level of desulfurization. The effect of particle size, however, was found to be quite negligible, indicating that the costly operation of crushing to very fine sizes is unnecessary.

Most recent studies have shown that magnetic iron sulfides can be produced by heating the chars in a slightly oxidizing atmosphere at about 550°C. Thus, magnetic separation techniques can be used to further reduce sulfur levels in the chars. Other recent data indicate that magnetite is a scavenger of the hydrogen sulfide produced during char hydrodesulfurization; it lowers the sulfur levels in char while lessening the amount of hydrogen off-gas clean up. Preliminary experiments indicate the sulfided magnetite is readily removed by magnetic means.

Table 1. Hydrodesulfurization of chars produced from some high-sulfur Illinois coals[a]

Run No.	Sulfur content (%)		
	Coal	Char	HDS Char
Preoxidized			
34	4.10	2.84	0.91
33	4.10	2.84	0.92
40	4.10	2.84	0.83
100	4.03	2.87	0.806
101	4.03	2.87	0.598
102	4.03	2.87	0.915
103	4.03	2.87	0.677
74	5.13	3.80	1.84
77	5.13	4.01	1.95
Nonoxidized			
55	4.10	3.05	1.12
52	4.10	2.71	1.06
50	4.10	2.71	0.88
75	5.13	4.58	1.95
78	5.13	4.09	1.67
81	5.13	4.09	2.04

[a]Chars were treated with 1 atm H_2 for 90 minutes at 750° to 850°C and 500 to 1000 cc/min in a 1-inch fludized-bed reactor.

High-Temperature Capture of Hydrogen Sulfide Using Spent Oil Shale (Rostam-Abadi, Kruse, Mirza, and Stephenson). The co-mining and co-processing of eastern oil shale and coal is potentially attractive in regions where deposits of oil shale occur above coal (Illinois, Indiana, and Kentucky). Hydroretorting processes increase the oil yields for eastern shales significantly. With regard to utilization of eastern, high-sulfur bituminous coals, a promising approach is first to recover readily condensable liquids and light gases by pyrolysis and then gasify the residual char. Co-processing of these two abundant resources in one plant or in adjacent plants would reduce the cost of transporting the spent shale. In the regions where co-mining is economically attractive, the spent shale would be used as sorbent for the hot gases produced during coal or char gasification.

The key to such an undertaking is the effectiveness of spent oil shale (eastern and western) to remove hydrogen sulfide from a stream of gas at high temperature. At the ISGS, researchers have been investigating the thermodynamics of reactions involving calcium and iron-bearing minerals as sorbents. These minerals are present in oil shale. Phase stability diagrams showed that under usual conditions found durng hot gas desulfurization, minerals in spent shale react with hydrogen sulfide at gas concentrations as low as 50 ppm for calcium-rich shales and 3000 ppm for iron-rich shales.

Samples of spent oil shale from Illinois and Colorado were prepared under inert, reducing, and oxidizing conditions. Sulfidation rates of the spent shales were obtained by a thermogravimetric method in the temperature range between 600° and 850°C. The reactant gas mixture was composed of hydrogen sulfide (0.3%), hydrogen (50%), and nitrogen. For these samples, more than 90 percent of the sulfur captured occurred in the first 5 minutes. The oxidized shales had the highest reactivities. For these, the chemical reduction of iron oxides was the precursor to the sulfidation reaction. The sulfidation capacity of hydroretorted shales increased with decreasing sulfidation temperature. The capacity of a typical eastern shale from Illinois was 29 pounds of sulfur per ton of hydroretorted shale and 44 pounds of sulfur per ton of oxidized shale.

Reactivity and Combustion Properties of Coal and Coal-Derived Solid Fuels (Rostam-Abadi, DeBarr, R. Frost, Harvey, and Kruse). Thermal coal-desulfurization processes designed to yield a solid fuel for boilers reduce the fuel's volatile matter content. This reduced volatility influences combustion characteristics such as ignition time and temperature, flame stability, and carbon burn-out in as yet unquantified ways.

To study these aspects, the Illinois Coal Development Board (ICDB) is partially funding the determination of combustion and gasification characteristics of an Illinois coal at three levels of partial devolatilization. The three levels of partially devolatilized fuel samples were produced from Illinois coal, IBCSP No. 3 (Illinois Basin Coal Sample Program, Coal No. 3), in the Mild Gasification Unit (MGU) at United Coal Company Research Corporation (UCCRC) in Bristol, Virginia. The samples produced had volatile matter levels (dry basis) of 11.4, 15.4, and 23.0 percent, respectively. The volatile matter content of the raw coal was 35.7 percent. The samples were shipped to the ISGS on November 15, 1986 and were subjected to a series of screening, crushing, and riffling sequences to prepare representative subsamples for ISGS, Argonne National Laboratory (ANL), and the University of Illinois at Urbana-Champaign (UIUC).

Using thermogravimetry (TG), the ISGS is obtaining reactivity data on combustion characteristics to compare with (1) the results of fluidized-bed combustion (FBC) testing at ANL, and (2) the flammability characteristics of the fuels as determined in an Entrained Dust Flow Facility (EDFF) at the UIUC. One goal is to determine the confidence level of TG in assessing the combustion characteristics of fuels in larger scale combustion equipment, thus eliminating some of the more costly tests.

A second aspect of this project is to determine and compare the reactivities of various coal-derived, desulfurized fuels prepared by two ISGS projects currently funded by ICDB through CRSC. Information on combustion and gasification characteristics of the desulfurized solid products is essential to assess its suitability as a solid fuel. Because none of the projects is at a scale large enough to produce quantities of desulfurized solid fuels for large-scale testing, reactivities are determined by thermogravimetry, which requires only milligram quantities of sample. The results will be used to assess the influence of operating conditions on reactivities and to find a relationship, if any, between the reactivities and the physiochemical properties of the samples.

Desulfurization of Illinois Coal Using Carbon Monoxide and Ethanol (Shiley, Hughes, Warren, P. Fox, and Redding; C. C. Hinckley and G. V. Smith, Southern Illinois University). The carbon monoxide/ethanol process could open up new markets for two of the state's natural products: coal and corn. For each million ton of coal desulfurized by the process, 3.3 million bushels of corn would be used to produce the required amounts of ethanol. As an outgrowth of this promising project, six patents were applied for during the past year.

External funding has continued over the past 4 years with grants coming from the Illinois Coal Development Board through the CRSC, and in the last year, from the Illinois Corn Marketing Board.

The three-step chemical/pyrolytic coal-cleaning process has removed 92 to 97 percent of the total sulfur from the nine Illinois coals tested. An average of 70 to 75 percent of the coal is recovered as a high-volatile, coal-like fuel. By-products, which include carbonyl sulfide, acetaldehyde, hydrogen sulfide, high-quality oil, fuel gas, and elemental sulfur, should contribute to the economic feasibility of the process. This coal product is in compliance with existing SO_2 emission standards as well as with those proposed by the U.S. EPA. ISGS engineers have estimated the cost to be about $50 per ton or $2.25 per million BTU. When allowance is made for the cost of scrubbers to meet SO_2 emission standards, the cost of coal/char is competitive.

The laboratory-scale process, which uses a batch/gas flow reactor, includes three steps: (1) coal is reacted with carbon monoxide at 300° to 350°C and 300 psig; pyrite and marcasite (FeS_2) are converted to troilite (FeS) with up to 50 percent of the pyritic sulfur being removed as carbonyl sulfide (OCS) and hydrogen sulfide (H_2S); (2) treatment with ethanol is conducted at 350° to 550°C and 300 to 400 psig, using troilite as a catalyst in the dehydrogenation of the ethanol to acetaldehyde and in the reaction between the resulting atomic hydrogen and organic sulfur to form H_2S; and (3) the iron-sulfide catalyst is removed by either of two oxidation methods. The most likely method for step 3 is partial oxidation (300°C, 2% O_2) of troilite

to form iron oxides and sulfur dioxide (SO_2), which is also being studied. Preliminary data indicate that complete oxidation can remove up to 70 percent of the sulfur in pyrrhotite. Following partial oxidation of the coal product, even treatment with a hand magnet can result in removal of up to 80 percent of the catalyst.

Flowing-gas conditions are essential to prevent backreaction between coal and carbonyl sulfide and/or hydrogen sulfide, and increasing the coal/reactant contact greatly improves desulfurization.

Current research involves improving the process through thermogravimetric studies and modifications in reactor design. Reaction rates in step 1 can be enhanced by using a carbon monoxide-ethanol mixture rather than carbon monoxide alone; and reaction rates in step 2 can be improved by the addition of small amounts of radical initiators such as NO or O_2. Experiments underway use C^{13}- or C^{14}-labeled reagents to provide precise material balances during steps 1 and 2. Funding is being sought for a laboratory- or demonstration-scale, continuous-reactor system that will allow the three steps to be conducted rapidly in sequence.

Sulfur Removal from Illinois Coals by Rapid Microwave Heating in the Presence of Gases (Shiley and Hughes; R. Varma, Argonne National Laboratory; D. Buchanan, Eastern Illinois University at Charleston; C. C. Hinckley, Southern Illinois University). The process uses ethanol in the presence of 2.45 GHz microwaves to desulfurize coal. All of the organic and half of the inorganic sulfur can be removed in two steps. First, a mixture of carbon monoxide and ethyl alcohol, in the presence of 2.45 GHz microwaves, is used to convert pyrite/marcasite in coal to troilite. Second, the coal is treated with 2.45 GHz, 50 MHz, 90 MHz microwaves, or combinations of each in the presence of ethanol, which serves as a hydrogen source for the removal of organic sulfur as H_2S. The two steps are performed under flowing-gas conditions at moderately elevated temperatures and pressures. The remaining inorganic iron-sulfide minerals are separated in a magnetic separator after mild oxidation.

Integrated Study of the Chemical and Mineralogical Behavior of Sulfur in Coal During Thermal Desulfurization (Coleman, Liu, Hackley, and J. Frost). Highlights of this project include (1) the development of a unique stable isotope tracer technique capable of monitoring the mobility (volatility) of the two major types of sulfur (organic and pyritic) during desulfurization processing, and (2) the discovery of a simple partial oxidation method for coal char to convert pyrite into a magnetic form of pyrrhotite that is highly susceptible to conventional magnetic separation. The project was funded by the CRSC and was successfully completed in August 1986.

Desulfurization of Illinois Coals by Thermal, Chemical, and Magnetic Methods: Optimization of Magnetic Conversion and Separation of Sulfide Minerals in Char (Liu, Hackley, and Coleman). The primary objectives of the project are to determine the best combination of methods and techniques to use for the thermal and magnetic desulfurization of Illinois coals. This includes optimizing thermal treatment conditions for the conversion of pyrite to magnetic pyrrhotite, and subsequently, effecting a magnetic separation of pyrrhotite from the resulting char.

In the first part of the project, three pyrolysis parameters (temperature, oxygen concentration, and treatment time) thought to control the formation of magnetic pyrrhotite from coal pyrite were all tested. The results show that if pyrolysis temperature is kept below 650°C, the formation of magnetic pyrrhotite can be achieved quite easily over wide ranges of oxygen concentrations and soak times. The fact that magnetic conversion of pyrite in coal is not greatly sensitive to the pyrolysis environment should simplify the design of larger thermal and magnetic desulfurization systems using this approach.

Location of Isotopically Characterized Coal Samples (Hackley, Liu, and Coleman). Differences in concentrations of stable isotopes have proven effective for monitoring the mobility of different sulfur forms during thermal and chemical treatment of coal. Desulfurization studies would benefit from research that identifies and samples Illinois Basin coals exhibiting distinctive distributions of sulfur isotopes. Samples could be made available for coal research.

ISGS researchers have taken 80 samples representing five sites in two underground mines located in central and southern Illinois. Thus far, the isotopic analyses show that two sites have the potential of yielding isotopically suitable coal samples. Current plans are to return to the two sites and expand the sampling area to learn if the isotopically distinctive characteristics persist horizontally in the coal seam and to correlate the isotopically suitable coal samples with local geology. Such correlation should facilitate the task of locating other appropriate coal samples.

Illinois Basin Coal Sample Program (IBCSP) (Kruse, Rapp, J. Cooper, Ruch, Ehrlinger, and Harvey). The IBCSP was established in 1983 by the ICDB to obtain, preserve, and distribute Illinois Basin coal samples to researchers. In December 1986, Indiana added a sixth sample to the program; it was collected at a southwestern Indiana preparation plant that processes Indiana V seam coal (Springfield No. 5 in Illinois). The Indiana sample was obtained from the preparation plant when it was operating on freshly mined coal. Crushing, screening, homogenization by repeated riffling, and packaging in 55 gallon barrels was conducted at Marion, Illinois, by Cepheus Industries under the direction of ISGS personnel.

The mine-washed IBCSP samples 1, 2, 3, and 6, which are Illinois Herrin (No. 6), Colchester (No. 2), an 80 to 20 percent blend of Springfield (No. 5) and Herrin (No. 6), and the recently added Indiana V, respectively, are supplemented by a tipple sample (IBCSP sample 4) and a channel sample (IBCSP sample 5) of Illinois Herrin (No. 6). The fifth sample is of higher quality than the others because it was maintained in an argon atmosphere from the mine to the processing facility. All additional processing was carried out in Argonne National Laboratory's inert atmosphere facility designed for the Premium Coal Sample Program (PCSP) funded by the U.S. Department of Energy.

Process Mineralogy in Support of Coal Desulfurization (Hughes, Warren, J. Fox, and Glass). This project continues to provide analytical support for three desulfurization projects. Significant improvements have been made during the year in data reduction and analysis on existing instruments. A new, computerized X-ray diffractometer, which was obtained and installed as a result of "Build Illinois" funding, promises to yield significantly improved results and increase productivity in the laboratory.

Rates of Microbial Removal of Organic and Inorganic Sulfur from Illinois Coals and Coal Chars (Risatti and K. Miller). The purpose of this study was to determine the viability of using bacteria to remove sulfur from coal chars and to investigate the reported ability of the bacterium Sulfolobus acidocaldarius to alter organic sulfur compounds and to remove organic sulfur from 200-mesh coals.

Thiobacillus ferrooxidans removed 89.6 percent of the sulfur present as pyrite from a 200-mesh Illinois No. 6 Coal in 27 days, at a maximum rate of approximately 12 percent per day. In a comparable experiment, approximately 55 percent of the sulfur present as troilite was removed from the same coal after charring by the carbon monoxide/ethanol method. Further demonstrations included removal of 50.7 percent of the inorganic sulfur from a char produced from Illinois No. 5 Coal and 41.9 percent of the inorganic sulfur from a char produced from an Illinois No. 6 Coal in a fluidized-bed reactor.

Sulfolobus acidocaldarius and Sulfolobus solfataricus are principally heterotrophic organisms and, as such, cannot significantly decrease the pyritic sulfur content of coals. Sulfolobus spp. do not appear effective for rapid removal of sulfur from coals. Results indicate that they are inconsistent in their activities; whereas thiobacilli can be used reliably to reduce the pyritic sulfur content of coals and coal chars.

Microbially Enhanced Physical Separation of Pyrite from Illinois Coals (Risatti and K. Miller). The ISGS and Northwestern University (NU) are working together to develop microbial methods to augment coalescent/flotation processes for physical desulfurization of Illinois coals.

Recent evidence suggests that cultures of the iron- and sulfur-oxidizing bacterial species, Thiobacillus ferrooxidans, act as suppressants in physical separation processes; some achieve efficient rejection of pyrite and ash in a matter of minutes. By including cells of Thiobacillus ferrooxidans in an aqueous coal slurry, it has been possible to double the percentage of pyrite rejected for oil agglomeration separations; and whole cultures of a similar organism have produced a 40 percent increase in pyrite rejection for froth flotation separations. These results may be due to (1) bacterial cells, selectively attached to pyrite, acting as wetting agents; or (2) a pyrite wetting agent elaborated by the organisms and released into the culture medium. The precise mechanism, however, has not been elucidated.

Cultures of Thiobacillus ferrooxidans and Leptrospirillum ferroosidans, organisms that oxidize only iron, are under study as possible suppressants for use with agglomeration and flotation cells. In experiments at the ISGS, small-volume assays are being tested for rate and extent of suppression and effects of contact time, contact pH, contact temperature, solution ionic strength, and growth stage of the culture. Optimum conditions are also being determined. Researchers at NU will use this information to engineer various scaled-up processes. While the engineering phase gets underway, the ISGS will attempt to explain the wetting mechanism and identify the optimum conditions for its operation.

Effects of Some Anionic Flocculants and Their Concentrations on Settling Rates of Coal and Underclay Slurries (Khan, Baxter, and Berggren). In processing of many minerals, considerable quantities of fine particles are gener-

ated and discarded into tailing ponds. These rejects settle slowly, are difficult to dewater, and may cause environmental, aesthetic, economic and handling problems. To better understand and control settling rates of coal and underclay slurrries, studies were made of the effect of pulp density, pH of media, and type and concentration of flocculants. These studies have shown that reprocessing rejects from coal-washing plants can be profitable. The processing cost will be lower and the profit margin greater when the material can be segregated or reconcentrated before reprocessing. For coal-washing plant rejects, segregation induced by selective flocculation of some coal slurry constituents and dispersion of others before their discharge into tailings ponds can lead to preconcentration of coal, sphalerite, and clay in the ponds.

OIL AND GAS

Economic Trends and Industry Activity (Leighton). The most serious short- and long-term energy problem in the United States has been identified recently in a DOE report as the inadequate supply of domestic petroleum for transportation fuels. Of major concern are the recent developments in the oil industry that have impacted so significantly on the nation's energy supply, economic development, and competitive edge. The price collapse this past year in the oil industry sent prices tumbling, led to major reductions in exploration and production expenditures, caused industry-wide reconstruction, new expenditure patterns, a reduced tax base, and massive layoffs.

These impacts nationwide have been substantial. Drilling expenditures for 1986 were less than half those made in 1985. Rig count is significantly down. Seismic crews are at the lowest level since the 1930s. Exploration efforts have been seriously curtailed. R & D expenditures have been slashed, federal involvement restricted, and stability lost.

For the first eight months in 1986 in Illinois, the average rig count was down 80 percent, and the average number of monthly drilling permits was down 60 percent. The average monthly production for the period July through December declined 20 percent; however, increases in production earlier in the year (January and February) helped annual production to reach an estimated 27,317,000 barrels--still 9.7 percent less than in 1985. The production is shown in table 2.

Independent oil producers in Illinois have been made especially vulnerable. Many stripper wells have become too costly to operate and have been shut-in. Low prices have been insufficient to justify risk taken in exploration. Captial necessary for the continued support of independents has been severely restricted as banks have become reluctant to finance high risk ventures under low price scenarios. Both the lack of capital and lack of research capability are strongly inhibiting the ability of independents to find domestic reserves and maintain supplies--to continue their role as a major source of oil and gas production in the United States.

The result is a rapidly widening gap between consumption and production with demand outstripping domestic supply. The widening gap means increased imports to meet the nation's balance of payments, security of supply, and defense needs. Imports are expected to make up more than 50 percent of the

Table 2. Production Decline in 1986 in Illinois

	MB/mo.	% Change from 1985
January	2644	+17
February	2650	+28
March	2502	-1
April	2376	-9
May	2267	-12
June	2201	-10
July	2241	-17
August	2017	-24
September	2158	-15
October	2158	-21
November	1922*	-25
December	2026*	-20

*Estimated

nation's supply of crude oil by the early 1990s, putting the United States in a steadily worsening position with growing vulnerability. As the world's excess capacity is reduced, OPEC is expected to gain a greater share of the market and once again be in a position to increase world price significantly. Of major concern is the ability of this nation to respond when this happens--to have choices to make rather than being forced to make a choice.

Against this back drop, the Illinois State Geological Survey is attempting to position itself to be of maximum help to industry and to the needs of the state. It has shifted gears to expand its program of research and service in oil and gas. Its goals are to help industry find economic means of getting more oil out of the fields already discovered, to provide additional ideas and incentives to industry, to explore for and develop Illinois' oil and gas resources, and to provide more complete and timely information to industry.

Oil and Gas Program for Illinois

The ISGS Oil and Gas Program aids the petroleum industry in exploration and development of Illinois resources by providing the comprehensive data collection, mapping, and subsurface stratigraphic research required to generate new petroleum targets and new techniques for exploiting existing fields and plays. Recently, new research has been directed toward discovering how and when oil was generated in Illinois and toward improving oil recovery from Illinois reservoirs. In recognition of the importance of economically available energy to Illinois, the Oil and Gas Section has embarked on a project designed to help industry recover as much oil as possible from the state's oil reservoirs. The addition of the first petroleum engineer in 14 years to the staff represents a major commitment to this project. T. D. Clawson, reservoir engineer, brings 6 years of oil company expertise to this effort.

Oil and gas data are made available to the public via (1) an annual report on the petroleum industry in Illinois; (2) a monthly drilling report; (3) oil and gas pay zone maps (showing the geographical area underlain by oil production from individual rock layers); (4) maps showing the subsurface depths of selected strata; (5) special publications; and (5) the Geological Records Unit. The state-mandated repository for well records contains over 270,000 files. This past year, J. D. Yeko was hired to be the first Geological Records Unit head responsibile for both the records and the oil and gas statistics.

Database for Oil and Gas

Annual Statistics and Records (B. Huff and Black). From the wells drilled each year, geological records, including well logs, are provided to the Survey by industry in accordance with state laws and regulations. Although drilling activity was considerably reduced this past year, the number of wells reported to the state increased. Apparently, the slack time in drilling allowed companies to get caught up with their records and submit them to the state. A tabulation of the number of holes reported by the Oil and Gas Industry in 1986 follows:

	1986
Oil and gas tests	
New holes	2,458
Old holes drilled deeper	97
Service wells	
New holes	10
Old holes drilled deeper	1

The 2,445 new holes reported in 1986 resulted in 1,325 oil wells, 41 gas wells, and 1,079 dry holes. Illinois ranked seventh in the United States in total wells reported in 1986, and fifteenth in total oil production. The following 13 counties accounted for 68 percent of the reported new holes drilled.

County	Number of holes	State totals
Crawford	297	12.1
White	175	7.2
Clark	156	6.4
Wayne	152	6.2
Schuyler	131	5.4
Brown	118	4.8
Jasper	115	4.7
Edwards	99	4.0
Clay	93	3.8
Lawrence	92	3.8
Fayette	84	3.4
Jefferson	77	3.1
Marion	76	3.1
Total	1,665	68.0

In 1986 discoveries reported included 1 oil field, 3 gas fields, 34 new pay zones in existing fields, and 42 extensions to the fields; the new fields are all small.

Reservoir Geology

Reservoir Heterogeneity (Oltz, Seyler, and Hughes). Illinois reservoirs retain well over half the discovered oil during routine production. To improve oil recovery, a major study of the chemical and physical characteristics of Illinois reservoirs has been undertaken. A recent upgrade in X-ray diffraction equipment and the acquisition of a scanning electron microscope (SEM) will permit screening of Illinois reservoirs. Significant differences in clay content, types of clay minerals and cementing minerals have been revealed in several Illinois reservoirs. These differences are expected to affect well productivity. Further study and evaluation utilizing X-ray diffraction, porosity, permeability, and core flooding information should lead to improved completion practices and improved recovery techniques.

It is believed that detailed sampling and analysis of the mineral composition of oil reservoirs in the state will prove especially helpful in this regard. Current studies of the Oil and Gas Section and earlier work by Smoot have shown that wide variability exists in clay mineral composition and that certain strata contain almost pure chlorite, fibrous illite, vermicular kaolinite, or smectite. Each of these clay minerals reacts differently with chemical and physical agents used for enhanced recovery. For example, acid stimulation will plug the formation, if illite and/or chlorite are present, while kaolinite and smectite will be relatively unaffected. The result of improper recovery procedures can increase or decrease production two- to one-hundred fold. With so many marginal wells in Illinois, an understanding of the clay minerals present in reservoirs is essential for efficient resource recovery.

Pool Studies (Crockett). Compilation and publication of the oil field pool studies accumulated in the Oil and Gas Section has begun. The studies will be released singly in map form.

Exploration Geology and Geophysics for Subtle Traps

Petroleum Geology of Lower Chesterian Sandstones in the Illinois Basin (Seyler). Research on stratigraphic traps in the sandstones and limestones of the Aux Vases Formation is designed to increase understanding of the deposition and distribution of an important reservoir rock and provide a model to predict the location of reservoirs.

Our research has shown that stratigraphic traps in the Aux Vases are complex and consequently poorly understood. They are dependent on lateral changes in grain size and thickness of the unit. Areas with the greatest potential for future production are being delineated using electric logs, cores, and outcrops. Stratigraphic traps in other Chesterian units (e.g., Cypress, Waltersburg, Bethel, and Tar Springs Sandstones), indicate that detailed study of environments of deposition will aid in developing an exploration model for subtle traps in these units.

Shallow Petroleum Occurrences in West-Central Illinois (Seyler and Crockett). A 5-year exploratory effort of nationwide interest has focused on Silurian oil accumulations 450 to 650 feet deep in the area east of Quincy. Geologic mapping has revealed that the largest oil accumulations in this part of Illinois occur in the dolomitized basal portions of relatively thick Silurian Kankakee carbonate strata that were deposited in subtle paleovalleys eroded in the underlying Ordovician Maquoketa Shale. The delineation of this paleodrainage pattern may prove to be a key factor in the search for additional hydrocarbons in similar traps.

Hydrocarbon Accumulation in Lower Pennsylvanian Sandstones (Howard and Whitaker). About 10 percent of the Illinois Basin's oil production has come from poorly understood and virtually undocumented traps in relatively shallow lower Pennsylvanian sandstones of southeastern Illinois. Many of these traps are associated with sediments that buried a network of paleovalleys eroded in pre-Pennsylvanian strata. One such trap containing nearly 1.4 million barrels of recoverable oil was accidentally discovered near Hardinville, Crawford County. This hydrocarbon reservoir will serve as a model for exploration for similar traps elsewhere in southern Illinois.

Hydrocarbon Related to Basal Pennsylvanian Paleovalleys in Edwards, Wabash, White, and Gallatin Counties, Illinois: A Play Model (Howard and Whitaker). A regional study of hydrocarbon accumulations related to the distribution, character and infilling of a network of paleovalleys at the Mississippian-Pennsylvanian unconformity has begun. The study's goal is the development of exploration models for stratigraphic traps in strata associated with these paleovalleys and their sedimentary fill.

Exploration Model for Tar Springs Hydrocarbon Reservoirs in Illinois (Whitaker and Clawson). Significant hydrocarbon reserves in Tar Springs sandstones have been discovered in southeastern Illinois. A detailed study of the depositional systems and of the conditions of hydrocarbon entrapment within Tar Springs strata has begun. This study will present play models that will aid in future exploration for significant Tar Springs hydrocarbon reservoirs.

Silurian Pinnacle Reef Distribution in Illinois: A Model for Hydrocarbon Exploration (Whitaker). Approximately 92 million barrels of oil has been produced in Illinois from Silurian pinnacle reefs and from younger sediments draped over these reefs. Exploration for these traps has largely been limited to a narrow trend stretching from Randolph County in the southwest to Cumberland County in the northeast. Evidence and interpretations presented in this report suggest Silurian pinnacle reefs were originally distributed across a much larger portion of Illinois than the present producing trend indicates. Erosion of Silurian strata prior to Middle Devonian deposition, particularly along an emergent Sangamon Arch, removed pinnacle reef structures in some areas of Illinois. Popular exploration methods used in the basin are not proficient in detecting reefs in these areas. Applications of geophysical and detailed lithologic surveys could enhance the likelihood of detecting partly eroded, but still productive, pinnacle reefs across a significant portion of Illinois.

Seismic Acquisition, 1987 (Oltz). Two geophysical companies donated seismic record sections to the Survey. One set, to be used in the AAPG Sag Basin Volume, has been interpreted. The other set is currently under review

by a seismic stratigraphy expert. Both will contribute to the knowledge of the Illinois subsurface.

Source Rock and Migration Studies

Organic Geochemistry of Illinois Basin Crude Oils and Source Rocks (Risatti and Dickerson; J. Hatch, USGS). The objectives of this project were to (1) apply modern organic geochemical methods to Illinois Basin crude oils in order to determine their characteristics, genesis, and relationships to each other as well as to other oils, (2) evaluate the organic carbon fraction from suspected source rocks to determine their relationships to Illinois Basin oils and their hydrocarbon potential, and (3) identify and study biomarkers from Illinois Basin source rocks and crude oils as possible indicators of oil migration and thermal maturity in the basin.

Middle Ordovician Guttenberg Formation in the Illinois Basin area: Thickness, Distribution, Lithofacies, and Source Rock Potential (M. Chou, Sargent, J. Treworgy, and Kolata). Recent studies by the USGS and ISGS indicate that the shale in the Guttenberg Formation has excellent hydrocarbon source potential (substantially high total organic-carbon content, high hydrogen index, and moderate level of thermal maturity). Little is known, however, concerning the distribution, lithologic characteristics, and organic geochemistry of the Guttenberg in the Illinois Basin. This study combines geologic and geochemical parameters to evaluate the Guttenberg as a source of petroleum.

Petroleum Source Rock Potential of the New Albany Shale (M. Chou and Dickerson). One hundred and forty-one samples taken from seven cores from three different geographic areas were analyzed. Results indicate that samples from western Illinois contain mixed kerogen of types I, II, and III, and are immature sources with respect to oil generation. Samples from eastern and southeastern Illinois, on the other hand, show a greater abundance of type II kerogen, and are moderately mature sources within the oil generation window. Samples from extreme southern Illinois containing mature type III kerogen are poor sources for oil generation, but may have some gas generation potential.

Organic Geochemistry of Some Source Rocks and Petroleum in the Illinois Basin (M. Chou, Dickerson, and S. Chou). Based on GC fingerprint analysis, 63 crude oil samples in the Illinois Basin were categorized. The majority of the samples (59) can be divided into one of two types. Type one oils include the majority of Silurian and Devonian oils as well as all the younger crude oils. These crude oils contain generally smooth normal alkane distributions with moderate amounts of pristane and phytane. Type two crude oils contain the common characteristics of Ordovician oils. They demonstate strong odd-carbon predominance between C_{15} to C_{19} n-alkanes, low concentrations of pristane and phytane, and a paucity of C_{20+} n-alkanes.

The preliminary geochemical study on shales and oils suggests that the New Albany Shale samples within southeastern Illinois and adjacent western Indiana may be responsible for type one crude oil accumulation, and the organic-rich Middle Ordovician Shale samples may be responsible for the type two, Ordovician-Trenton oil accumulation.

Hydrocarbon Source Rock Study in Central Western Illinois (Crockett, Oltz, Dickerson, and Autrey). Source rock screening studies of Ordovician rocks in Illinois have identified portions of the Maquoketa Shale as having very good hydrocarbon source potential. Six samples of dark, presumably organic-rich Maquoketa Shale from the shallow subsurface (500 to 800 ft deep) from McDonough, Schuyler, and Fulton Counties in western Illinois were examined. Results from geochemical analyses (total organic carbon and rock-evaluation pyrolosis) suggest that the Maquoketa is a very good source rock. Further studies at ISGS will expand upon these preliminary results.

Oil Migration (Hughes, Warren, Moore, Crockett, Seyler, Glass, and Austin). The discovery in the past year of a method to differentiate detrital from diagenetic illite represents a major advance for this project. This discovery helps to identify the potential of an argillaceous rock unit to produce diagenetic water that transports oil to reservoirs. The method also aids in the resolution of several other geological problems, because detrital and provenance effects can be distinguished from post-burial alteration.

Natural Gas Investigations

Flow Testing of Oil and Gas Wells (Riley). To date, 43 gas and gas/oil wells have been tested to determine gas flow rates to aid the operators in determining the commercial feasibility of producing from the wells and to provide a database for future oil and gas finds. This gas well testing service is the only one of its kind in the state, apart from in-house testing by major gas companies done strictly for their own wells. As a result of our testing and consultation, natural gas that would have been flared or shut-in is now being put to use.

Geochemistry of Natural Gas (Riley, Liu, and Coleman). As part of the gas and gas/oil well tests, samples of the natural gas are analyzed quantitatively by gas chromatography to determine composition, specific gravity, and BTU value. In addition, isotopic analyses are performed on certain samples collected. This year, 152 natural gas samples were collected in the field or submitted by gas producers needing precise analysis of their project. The information gained by these analyses not only helps the gas producers but also adds to our database and assists in distinguishing natural gases from different sources.

Computerizing Well Flow and Analysis Records (Riley). The Survey has been flow testing gas and gas/oil wells since the late 1930s. The results of these tests are presently stored in paper form only. In order to provide convenient access to the data in these reports, a computerized database has been established and the reports are being formatted and entered.

Potential Problems Related to Methane Gas Encountered While Drilling in Areas Containing Coal Mines (Whitaker and Clawson). Blowouts have occurred during well drilling in areas containing coal mines; occasionally they have resulted in property damage or death. Present regulations are inadquate regarding requirements for the observance of proper safety practices while drilling in such areas. Petroleum industry studies suggest that 5 to 20 trillion cubic feet of coal-associated methane can be recovered in the Illinois Basin. It is probable that exploration for this energy resource will increase. Our study will evaluate safety procedures applicable to this problem.

INDUSTRIAL MINERALS AND METALS

Industry News

Merger of Ottawa Silica and Pennsylvania Glass Sand (ROCK PRODUCTS/ January 1987). Ottawa Silica Company, Ottawa, Illinois, and Pennsylvania Glass Sand Corporation, Berkeley, West Virginia, have merged to form the U.S. Silica Company. Both Ottawa and Penn Sand are subsidaries of Pacific Coast Resources (PCR), an English company with international mining interests. According to a PCR official, the name change will help unify marketing efforts of the two companies. PCR claims the consolidation will make U.S. Silica the largest silica sand producer in the United States.

General Activities

23rd Forum on the Geology of Industrial Minerals (Industrial Minerals staff, Ehrlinger, Hughes, Harvey, Goodwin, and Reinertsen). The Illinois State Geological Survey will host the 23rd Annual Forum on the Geology of Industrial Minerals at the Saratoga Hotel in North Aurora, Illinois, May 11-15, 1987. Planning for the Forum is well underway in cooperation with the Office of Conferences and Institutes of the University of Illinois. A 1,300-name mailing list was prepared to inform industrial mineral workers in the United States and Canada about the Forum, the technical program, and field trips. Aggregate resources of the Chicago area and industrial sand operations in La Salle County will be highlighted.

Industrial Minerals Publications Listing Updated (Mikulic and Goodwin). Industrial Minerals Note 69, "Industrial Minerals Publications of the Illinois State Geological Survey Through December 1978," has been updated and revised to include more Survey publications on Illinois stratigraphy of interest to those engaged in exploration for industrial minerals and metals in Illinois. The revised list, arranged by mineral commodity and annotated, will be prepared for publication.

Industrial Minerals and Metals (Masters). A chapter with this title, prepared for inclusion in "Natural Resources of Illinois: Introduction and Guide," is scheduled for publication by Illinois Natural History Survey (INHS). The chapter contains a geologic thumbnail sketch of minerals produced commercially in Illinois, including limestone and dolomite, sand and gravel, peat, clay and shale, silica sand, fluorite, and tripoli. Sphalerite (zinc ore) and galena (lead ore) are recovered as by-products of fluorspar mining and are currently the only metals produced in Illinois. This article is intended to provide information on the nature of industrial minerals and metals mined in Illinois. Basic references are included to guide readers to sources of more detailed information.

Limestone and Dolomite

Inventory of Active and Abandoned Quarry Sites in Cook County (Mikulic). An inventory of all quarry sites in Cook County, Illinois, is nearing completion. Information about the size, location, geologic features, history of quarry operations, and current status of each site is included in the inventory. This information will be useful in several areas of geologic research, such as the groundwater conditions near filled quarries and foundation condi-

tions at these sites. The inventory will also provide basic data for research on various features of local geology, paleontology, and the history of the Chicago stone industry. Several unreported 19th-century quarry sites have been rediscovered.

Aggregate Resources of the Chicago Metropolitan Area (Mikulic). The economically important Chicago area stone industry is a major producer of aggregate, a key element in local construction. Urban expansion has encroached on many old quarry sites, forcing them to close, and there are very few locations left where quarries may be developed. To meet local demand for aggregate, it may be necessary to import it, at an increased transportation cost. This ongoing project examines the Chicago area geology to locate new sources that may be quarried and to aid existing operators in further developing quarries now in operation. To date, all operating quarries, along with most exposures in the Chicago area, have been examined to develop an understanding of the requirements of the stone industry and to improve knowledge of local Silurian stratigraphy. Well records for the area have been checked and cores have been logged to increase understanding of subsurface relationships and aid in predicting the availability and reserves of high-quality stone at new sites. Detailed field work has begun in Kankakee County, which may have the best potential for new quarry sites.

Possible Underground Mining of Limestone and Dolomite in Central Illinois (Baxter). The geology of several counties in central Illinois precludes the use of local sources of near-surface limestone or dolomite as construction aggregate or for other purposes. These counties include several major downstate metropolitan areas: Champaign-Urbana, Decatur, Springfield, and Bloomington-Normal. In these areas, clastic rocks (sandstone, shales) of the Pennsylvanian System occupy the bedrock surface and are overlain by a variable thickness of glacial drift. Limestone rock units of Pennsylvanian age are thin and/or have excessive thickneses of overburden.

Although gravel can be used to meet some of the aggregate needs in central Illinois, the shortfall can be eliminated by underground mining of thick, pre-Pennsylvanian carbonate (limestone/dolomite) by means of vertical shafts or inclines. Primary targets include the Ste. Genevieve, St. Louis, and Burlington Limestone (Mississippian), Devonian-Silurian formations, and the upper portion of the Galena Group (Ordovician). Data on thickness, depth, character, and minability of these deposits are being compiled and a report prepared.

Susceptibility of Selected Carbonate-Rock Aggregates to "D-Cracking" (Baxter, Harvey, Hughes, Warren, and Masters). ISGS researchers have conducted various investigations into the chemical, mineralogical, and petrographic character of samples from 12 selected carbonate rock aggregate sources in cooperation with IDOT's Bureau of Materials and Physical Research. Whole rock chemical analyses and XRD analyses of whole rock and insoluble residues have been completed, and petrographic studies are nearing completion. These data will be transmitted to IDOT for evaluation in terms of freeze-thaw durability and case histories of the use of these sources with Portland cement in concrete highways. The intent is to identify factors related to deterioration of concrete in highways and find a simple test for response to freeze-thaw conditions.

Sand and Gravels

Geologic Characteristics of Illinois Gravel Deposits Affecting IDOT Freeze-Thaw Test Results (Masters and Evans). The Illinois Department of Transportation (IDOT) initiated the freeze-thaw test (ASTM C666-77) as an additional quality control in order to eliminate "D-cracking" from Portland cement concrete highways in Illinois. The objective of this joint research project of the ISGS and IDOT was to identify the rock types in gravels that cause the expansion of freeze-thaw test beams and the variability of test-beam data.

Samples were collected from various gravel-producing areas and studied by (1) identifying and tabulating data on pebbles in the surfaces of slabs cut from test beams, and (2) separating gravel by rock types and independently freeze-thaw testing them in groups. Statistical analyses of the rock-type data indicated that chert, especially low specific gravity (<2.35) chert and ironstone, along with silty dolomite, and possible weathered carbonate, are the most expansive rock types in the gravels studied. Variability of the freeze-thaw expansion data is probably due to nonrepresentative assortments of pebbles located in the critical central core of the test beams and subtle variations of material within the sand and gravel deposits.

Specific Gravity Distribution of Chert in Gravel Compared to Freeze-Thaw Expansion of Test Beams Containing Those Gravels (Khan and Masters). The ISGS-IDOT gravel study identified low specific gravity chert (<2.35) as a deleterious material strongly related to increased freeze-thaw test-beam expansion. The specific gravity distribution of chert in six samples from the original study has been studied. The distribution curve is bimodal and reveals discrete populations of lower specific gravity chert (<2.55, mode about 2.4) and a higher specific gravity chert (>2.55, mode about 2.65). Chert with specific gravity <2.55 accounts for one-third to as much as two-thirds of the chert content of different samples. During freeze-thaw testing of beams containing larger proportions of the heavier chert, expansion decreased, but the relationship is not linear. Since there are two distinct types of chert, an unshared characteristic of the lower density chert might be used to mechanically remove the lower density chert.

Clays

Expansion of Database on Mineral Composition of Earth Materials in Illinois (Hughes, J. Fox, and Warren). This project, which involves the maintenance and augmentation of a computerized database and sample library on the composition of Illinois earth materials, continues to expand. The files and samples are organized to provide rapid responses to requests for information. The newly acquired, computerized X-ray diffractometer (funded by "Build Illinois") will improve the accuracy and speed of data entry, and should increase the number of new materials evaluated each year. The staff visits industrial minerals businesses whenever possible, and samples are acquired and analyzed to expand the database and evaluate future needs for new materials.

Metallic Minerals

Subsurface Geochemical Investigation in Western and Southern Illinois--A Pilot Study (Baxter, Masters, and Eidel; R. L. Erickson, M. S. Erickson, and B. Chazin, USGS). A report detailing the results of this pilot subsurface geochemical study of insoluble residues of Paleozoic carbonate rocks from 29 drillholes on a western Illinois transect from northernmost to southernmost Ilinois has been completed and is under review. The project is a cooperative effort by the ISGS and the USGS. Zinc is clearly the most abundant metal in insoluble residues from Ordovician, Devonian-Silurian, and Mississippian carbonate rocks. Lead is the most abundant metal in insoluble residues of Cambrian carbonates, a characteristic in common with Cambrian carbonates in southern Missouri. Anomalous amounts of all metals (Zn, Pb, Cu, Mo, Ni, Ag) and barium and strontium are present in southern Illinois, whereas zinc predominates in western Illinois. A Be, Nb, Th, Ti, Ba, F, Nb, Y, and RE suite is present in southernmost Illinois. Geochemical maps and bar graphs show the stratigraphic distribution and abundance of selected elements; they reveal regions of anomalous subsurface metal values, permit speculation about possible regional target areas, and help focus on specific concepts and models of mineral occurrence that should be tested.

Study results raise important questions about ore-forming processes and metal and sulfur sources that should generate promising new mineral resource research in Illinois. At least four different types of ore deposit models, based upon characteristics of known mining districts, should be considered in western and southern Illinois: (1) Ordovician-hosted and possible Devonian-hosted zinc-lead deposits in west-central and northwest Illinois similar to those in the Upper Mississippi Valley Zinc-Lead District; (2) new Mississippian-hosted fluorite, barite, zinc, and lead deposits in southwestern Illinois similar to known deposits farther east in the Illinois-Kentucky Fluorspar District; (3) Cambrian-hosted, lead-rich base metal deposits similar to those in the world-class Southeast Missouri Lead District; and (4) cryptovolcanic breccia-hosted deposits (Be, Nb, Y, Th, Ba, F, RE) similar to known occurences at Hicks Dome.

Midcontinent Strategic and Critical Minerals Program--Phase II (Baxter and J. Treworgy). As part of this cooperative project between the USGS and 12 midcontinent states, the ISGS prepared and delivered to the USGS during the reporting period an

- isopach (thickness) map of the Mississippian succession from the base of the Aux Vases Sandstone to the base of Valmeyeran or Kinderhookian Limestone (1:1,000,000), and a

- lithofacies map (limestone/dolomite ratio) of the carbonate rocks in that succession (1:1,000,000).

Expanded Mineral Resource Appraisal of Southern Illinois (Eidel, Baxter, and Survey staff). A USGS Coterminous U.S. Mineral Appraisal Program (CUSMAP) for the Paducah 1° x 2° Sheet in Illinois, Missouri, Kentucky, and Indiana became operational October 1, 1986. The objectives of this cooperative effort involving the Central Minerals Branch of the USGS and the various state surveys are to compile all existing geologic, geophysical, and geochemical data; identify and acquire new information to fill gaps in the database; and

complete an in-depth evaluation of the fluorspar, barite, base metal, beryllium, thorium, rare earth, coal, oil and gas, industrial mineral, and groundwater potential of Illinois south of the 38th Parallel. The recent release of $78,000 to the states to upgrade their GIS systems will allow the Paducah project to become the first CUSMAP project to be fully computerized. The use of digital techniques is first being implemented in a pilot study area consisting of four 7.5-minute quadrangles in Hardin, Pope, Gallatin, and Saline Counties in Illinois and adjacent portions of Kentucky, centered on the Hicks Dome cryptoexplosion structure.

Coal Section Contributions to CUSMAP (Damberger, Nelson, and C. Treworgy). Damberger, Chairman of the CUSMAP Coal Committee, chaired a meeting in Carbondale that developed a plan for products. He also participated in several planning meetings, and discussed data input by the Indiana and Kentucky Geological Survey with colleagues from these Surveys. Stratigraphic data are being collected and computerized, and this process is well advanced for the Paducah sheet. C. Treworgy directs the compilation of the stratigraphic database for the Pennsylvanian and for the coal resource maps.

Nelson chairs the Geologic Mapping Committee, coordinates the compilation of the bedrock map for the quadrangle; he has compiled a pilot geologic and structural map of four quadrangles surrounding Hicks Dome. The pilot study was digitized by the Computer Research and Services Section to test and develop ISGS-GIS capabilities for preparation and analysis of the final maps.

Baxter, Damberger, Masters, Nelson and others also organized and participated in the ISGS, MGS, KGS, USGS field trip for participants to the Captain Mine, attapulgite mine, various fluorspar occurrences in southern Illinois and adjacent Kentucky, and structural geology sites.

Attempts to Combat the Problems of Processing Fines (Khan and Baxter). The growing consumption of natural resources produces increasingly large quantities of minerals. The increase in the tonnage of mined material is partly caused by depletion of high grade material and the consequent reliance on low grade ores. Fine grinding of the ores is often required to properly size the feed and/or to liberate the valuable minerals. Fines that cannot be cleaned effectively are discarded in desliming operations before actual processing of the ore, a step that often results in rejection of considerable quantities of valuable material.

To combat this problem, preventive and corrective measures including controlled grinding, limited liberation, and processing at coarser sizes were considered. These measures encompass intensive aeration, aggregation of particles, intensive mixing, increased retention time, and reduction of detachment of particles from the bubbles during flotation.

Apparatus for Determining the Flotation Behavior of Small Quantities of Material (Khan and Baxter). A Halimond tube was constructed and apparatus set up to determine flotation behavior of small quantities of ore material (2 to 3 grams). Use of this apparatus allowed strict control of experimental conditions and improved reproductivity of the experiments; it is being used to determine the processing behavior of sphalerite, pyrite, shales, and clays, and will also be used in experiments on fluorite/barite separation.

MINERAL ECONOMICS

Illinois Mineral Industry in 1984 and Review of Preliminary Mineral Production Data for 1985 (Samson and Bhagwat). This report has been published as Illinois Minerals Note 95. A brief summary is included in the Mineral Resource introduction to this Annual Report.

Directory of Illinois Mineral Producers 1986-87 (Samson and Masters). This directory includes information on producers of all Illinois minerals except oil and gas. Producers of natural gas liquids, synthetic gas, and petroleum refineries are included. The producer names and postal addresses will be accompanied by data on exact locations on rock units mined. A map has been included to show locations of stone and sand and gravel producers.

Economics of Secondary Recovery of Coal (Khan, Bhagwat, and Baxter). Coal processing plants are being increasingly forced to handle larger quantities of finely ground coal generated either in the process of liberating embedded impurities or by mechanized mining. Significant quantities of fine coal, which are difficult to process, are subsequently discharged into tailings ponds. The accumulation of increasingly larger amounts of fine-coal waste over the life of an operation makes the exploitation attractive.

Two flow diagrams for the recovery of this coal have been designed and the economic feasibility of the secondary recovery process determined.

Domestic Utilization of High-Sulfur Coals: Trends and Prospects (Bhagwat). In view of the current clean air regulations for coal-burning plants, Bhagwat proposes that the definition of "high-sulfur" coal should be changed to include all coals containing about 1.0 percent or more sulfur. By this definition, 17 out of 24 coal-producing states must be categorized as "high-sulfur" coal states. This study concentrates on six of these states--Kentucky, Illinois, West Virginia, Ohio, Pennsylvania, and Indiana--which account for more than 75 percent of the U.S. pollution potential from coal-burning electric utilities.

A review of 1974-84 coal sales from the six states indicates an average annual growth rate of only 1.25 percent, compared with the national coal sales growth rate of 4 percent per year. Slow demand growth in the eastern half of the country has been the primary cause of slow production growth, but inroads by western low-sulfur coals into the traditional markets for the coal from the six states also contributed. Western imports by these markets increased from 19 to 48 million tons. States such as Kentucky and West Virginia could shift mining activities to lower sulfur coal areas, but other states possess no such fall-back possibilities. If no new environmental restrictions are introduced, coal production in the six states may increase by about 6 percent to 537 million tons by 1994 or at an average annual rate of 0.6 percent. If, on the other hand, an acid-rain law is passed and implemented soon, the six states will suffer a drop in production of more than 50 million tons, resulting in about 14,000 jobs lost in coal mining alone. Information from the study indicates how widespread the stagnation in the coal industry has been and how long it has persisted. Public policies geared toward overall economic growth are required for a brighter future for coal. Coordination of policies beyond state boundaries is vitally important.

Charles Zelinsky is superintendent of the Geological Samples Library, which houses one of the largest collections of geological samples in the United States.

Beverly Seyler uses the new scanning electron microscope (SEM) in studies of oil reservoir rocks in Illinois.

Factors Affecting Prices of Fossil Fuels in the United States (Bhagwat). Oil price increases of the 1970s and early 1980s, as well as the precipitious price declines of the past year or two, caused conflicting concerns for consumer and oil industry well-being in the United States. Oil price hikes were blamed for energy price increases in general, and the OPEC cartel is alleged to have been at the root of all the problems.

In this paper, Bhagwat analyzes 1973-1985 prices and other national and international data in order to identify factors that influence prices of fossil fuels. Statistical correlations indicate that structural changes in the U.S. economy away from manufacturing and toward services, the cost of finding a new barrel of oil, and the efficiency of energy use in wealth creation are the most significant domestic factors affecting energy prices. Supply restrictions by OPEC in 1974 triggered increased non-OPEC production and energy conservation. The lack of unity within OPEC led to divergent production behavior by some members, contributing to price declines since 1981. The divergence was, according to some economists, guided by long-term profit maximization tendencies, which in turn are influenced by expectations about future interest rates. Actual interest rates in the United States were found to positively correlate with domestic oil prices.

When completed, this economic analysis is expected to provide some insights into energy price behavior that will have implications for economic, tax, and foreign policy formulations.

Economic Foundations for a Subsidence Research Program in Illinois (Bhagwat). A white paper reviewing the issues impacting mine subsidence research and the economic importance of the research for the long-term welfare of the Illinois coal industry was prepared. The Illinois coal industry is caught between environmental problems caused by the high-sulfur content of Illinois coal and economic problems caused by intense price competition. Changing geologic conditions in future deeper mines add a third dimension to the problem, which can be tackled only by new and more productive mining technologies. These new technologies make it necessary to deal effectively with mine subsidence. Subsidence research must, therefore, be enforced today if Illinois coal mining is to adapt successfully to the needs of the next 25 years.

Basin Analysis Task Force

The purpose of the newly formed task force is to develop a sound geologic framework for the Illinois Basin area and to synthesize the vast amount of existing Illinois Basin data in order to stimulate economic growth and scientific progress. The approach is multidisciplinary, utilizing geological, geophysical, and geochemical data.

Interior Cratonic Sag Basin Volume (Leighton, Eidel, Kolata, Oltz, and others). The ISGS staff, working with geoscientists from the Indiana and Kentucky Geological Surveys as well as from academia and industry, are compiling one of five volumes to be published in the American Association of Petroleum Geologists (AAPG) Petroleum Basin Series. This series is intended to give a broad overview of significant fundamental basin types, basin evolution, and oil and gas plays, as well as distibution and size of oil and gas fields. The Sag Basin volume focuses on the Illinois Basin. The process of

compiling this information provides a unique opportunity to summarize what is known about the basin and also provides insight to develop the mineral resources of Illinois. The volume will serve as a fundamental reference on the Illinois Basin for many years.

Chapter 1, compiled by Buschbach and Kolata, discusses the geographic and general geologic setting, tectonic setting, major structural features, and stratigraphic framework of the basin. Chapter 2 begins with an overview of the Sloss sequences and is followed by discussions of the Sauk (Sargent), Tippecanoe (Kolata and Mikulic), Kaskaskia (J. Treworgy and Devera), Absaroka (Trask, Jacobson, Damberger, Williamson, and Williams) and Zuni-Tejas (Kolata) Seuqences. The chapter concludes with a comprehensive overview of biostratigraphy and its application to the chronostratigraphic framework (Norby). The structure of the Illinois Basin is the subject of Chapter 3. Papers by Heigold and Bertagne and Leising (Companie Geophysique Generale) discuss high-resolution seismic reflection transects across major structural features. A comprehensive discussion of structural styles in the Illinois Basin (Nelson) is also included in this chapter. Chapter 4, Tectonics and Basin Evolution, includes papers on crustal character and thermal history (Heigold), tectonic history (Kolata and Nelson), and origin and evolution of the Illinois Basin area (Kolata and Nelson). Chapter 5, Oil and Gas Systems, reservoir rock distribution (Howard), entrapment and play types (Seyler), diagenesis and reservoir parameters (Pryor), source rock characteristics and maturation history (Cluff and Oltz), crude oil/source rock correlation (M. Chou), pathways and migration (Bethke), volumes of discovered hydrocarbons (Mast), and future opportunities (Oltz).

Episodic Potassic Diagenesis of Ordovician Tuffs in the Mississippi Valley Area (Kolata; R. L. Hay, University of Illinois; Mingchou Lee, Case Western Reserve). Cambro-Ordovician strata of the Upper Mississippi Valley (UMV) have been extensively modified by potassic diagenesis. Ordovician vitric tuffs are altered to K-feldspar and illite-rich mixed-layer illite-smectite, which give dates suggestive of episodic diagenesis. Potassium-argon dates of K-feldspar indicate an age of about 400 Ma (early Devonian); illite of the UMV about 367 Ma (late Devonian); and illite of tuffs in Missouri about 275 Ma (Permian). These appear to be the times of major movements of subsurface fluids in the midcontinent area. These data have implications on the timing of hydrocarbon migration and formation of ore deposits.

Stratigraphy and Depositional Environments of Mississippian Mid-Chesterian Units in the Illinois Basin (J. Treworgy). Interpretation of the lateral and vertical lithofacies distributions of the siliciclastic Fraileys/Big Clifty and carbonate Haney Formations indicates that the Illinois Basin was a low-angle, low-relief ramp that was tectonically and tidally influenced during mid-Chesterian time. The southern end of the present-day Illinois Basin was a shallow, subaqueous sill that separated the Illinois Basin ramp from the epicontinental sea to the south. Three changes in relative sea level that affected sedimentation and the early diagenetic history of the sediments have been documented.

GEOLOGICAL RECORDS UNIT

The Geological Records Unit is the repository for drilling records in Illinois, including oil and gas wells, water wells, engineering borings, and miscellaneous test holes. This database is used heavily by the oil industry, coal industry, hydrogeologists, engineers, land-use planners, land owners, the general public, and staff. The following table summarizes GRU activity.

Collections	1986-87	Total
Processed drillhole records	10,941	277,057
Books of processed drillhole records	2	751
Skeleton logs (records of wells drilled prior to 1920)		17,950
Skeleton log books		40
Confidential log books		15
Out-of-state log books		14
Miscellaneous hole record books		9
Geophysical logs	7,247	118,905
Coal pluggings	1,149	19,029
Filing numbers - sample sets	414	65,875
Filing numbers - cores	127	13,181

Data Acquisition

Basic Data	1985-86	1986-87
Oil permits	4,437	1,826
Oil permit corrections	173	168
Water permits	5,831	7,002
Plugging affidavits (oil and water)	2,230	2,569
Logs		
Electric logs	2,028	3,145
Micrologs	288	478
Radioactivity logs	2,006	3,276
Miscellaneous geophysical logs	437	328
Total geophysical logs	4,759	7,247
Drillers logs	679	418
Drilling time logs	760	567
Company sample and core studies	199	311
Geologic tops	252	323
General data (completion information)	3,703	3,108
Water well and test hole logs	3,837	4,026
Miscellaneous	675	1,189
Total new logs received	14,864	17,189

While total orders increased, the size of each order decreased; therefore, revenues generated from sales are down.

Total orders processed	3,030	3,157

The Survey copy system, implemented in June 1984 under NRIF, continues to provide a vital service to the public. The average number of orders processed per month increased. Although visitor days decreased, file usage and orders increased. Increased acquisition of geophysical logs resulted from a mailing campaign to all delinquent drillers in cooperation with the Department of Mines and Minerals. The increase in water well permits, plugging affidavits, and geophysical logs more than offset the decrease in oil well permits.

Discussions were held between the ISGS and the Records Committee of the Illinois Geological Society. Valuable input regarding record access by industry and the desired records configuration was obtained. An increase in GRU staff permitted an attack on the "pending" file backlog. A one-year effort to consolidate the pending and regular files is underway.

All complete well information folders and pending oil and gas well folders are being consolidated into a single, expanded main room on the north side of the second floor to facilitate public access. The water well permits and engineering borings are being consolidated into room 230.

The Unit is proceeding with the overall computerization. Three personal computers were acquired and are beginning to be used in a variety of data entry and verification tasks.

This was a year of considerable change for the Geological Records Unit. New staff members, space, and equipment have revitalized the unit.

GEOLOGICAL SAMPLES LIBRARY

General

The ISGS Geological Samples Library Unit manages one of the largest collections of geological samples in the United States. The Samples Library staff receives, processes for storage, and archives these important collections of samples and cores as mandated by Illinois Statute (Chapter 96 1/2 - Natural Resources Conservation of Oil and Gas). The Geological Survey began collecting these samples in the early 1900s when the USGS donated a series of drillholes to the State Geologist. Today, this unique repository houses an information source that represents billions of dollars invested in Illinois by petroleum and mining companies. The collection attracts users from across the country, enhancing the investment potential in Illinois by both in-state and out-of-state companies.

Cuttings

During the past year, the permanent file of the Samples Library acquired 414 sets of well sample cuttings, representing more than 792,283 feet of drilling. These samples added 742 boxes and occupied an additional 9 linear feet of storage space. Because of decreased drilling activity in Illinois during the past year, 148 fewer sets were required for the files. Only 131 sets of cuttings were requested from permits issued last year, compared to 356 the previous year. The Samples Library files of 65,875 sets of well cuttings represent more than 740,864,027 feet of drilling, are stored in 100,672 boxes, and utilize 1,400 linear feet in a 3,780-square-foot area in the Samples Library.

Data from an additional 124 oil and water wells await processing. At present, the interval between receipt and permanent processing of samples is 12 months (no change from last year). The slowdown in drilling activity has allowed us to reduce the large number of wells for which data processing was at the Evansville Sample Cut, a commercial firm to which we subscribe. We began the year with a 150 well balance at the Sample Cut; today, the balance is 26 wells.

Additions to our permanent files consisted of 86 oil test sets from rotary drill wells washed, 175 washed sets purchased from Evansville Sample Cut, and 153 water well sets processed dry.

We continue to receive a high percentage of oil well sample cuttings requested and a much lower percentage of water well cuttings. The GSL has initiated actions to improve recovery of water well cuttings requested on permits.

Cores

During the reporting year, 127 core sets representing an initial 37,979 feet of drilling were collected, examined, and processed into the permanent files. Included in this year's additions were 14 cores representing 7,198 feet of drilling from Phase II of the Superconducting Super Collider in Illinois preliminary report. Also added were 14 core sets representing 1,281 feet of core from the COGEOMAP project. This year's additions represent an increase of 13 cores and 4,613 feet over last year's additions. The entire collection of 13,181 sets of core on permanent file (representing more than 881,679 ft of core drilling) is stored on steel racks in an area covering approximately 4,300 square feet of the Samples Library.

Other Sample Collections

During the past year, four Pleistocene (P-series) samples were processed into our permanent files. Our collection in this sample category now totals 23,742 individual samples. The Survey staff generates a large volume of research material. GSL staff receive, sort, and file these materials in the Staff Research Collections storage area of the Samples Library. More than 30,000 of these samples are on file at the Annex facility.

Supplies

The Geological Survey is required to provide sample bags for the collection of well sample cuttings that are requested on permits issued by the State of Illinois. During the past year, the Samples Library supplied drillers and operators with 18,950 bags for requested well cuttings. A decrease (40,200) from last year's total is indicative of the drilling slowdown in Illinois during the past year.

Geological Samples Library Service Activities

Requests for service increased again during the past year. Telephone requests regarding availability of samples or cores, location information, file numbers, and space to study samples are handled daily by GSL staff.

To ensure that the samples database continues to acquire samples required to provide a representative database for the state, the GSL office has a vigorous program to contact drillers by letter to inquire about delivery of requested samples from completed oil tests. In calendar year 1986, 147 letters regarding 184 wells were sent to drillers. Seventy-six responses (52%), about 93 wells, were received at the GSL office. Cuttings from 28 additional wells were received as a result of this year's program.

Visitors and staff members referred to our files 504 times (187 more times than in the previous year) and retrieved 788 sets of samples or cores for examination. About half of the increase (98) were visitors to the Survey; they totalled 287. Visitors to the Annex facility represent a wide range of geologic interests. Independent consultants and representatives of major oil companies, universities, and governmental agencies are typical visitors to the Samples Library. Of all visitors to the Samples Library, 59 percent were from out of state. The database has long been of value in attracting outside investment into the state.

Samples Library personnel assemble rock and mineral kits for distribution to Illinois schools. A 35-specimen rock, mineral, and fossil set is a collection designed to familiarize teachers and students with rocks and minerals of Illinois. This past year Samples Library staff assembled 111 specimen kits and filled 12 orders to recondition sets already assigned to schools.

The Samples Library office houses the Survey's microfiche collection of well log information and makes sales of copies or assists visitors who wish to examine this collection of 72,553 microfiche (6,392 fiche added).

Other Projects

In addition to normal operations, the GSL staff cooperated with Administrative Service Group to relocate the Reserve and Archive copies of Survey publications from the Annex facility to the new Shop and Equipment Building. This move allowed the GSL to complete a reorganization of the storage area of the Annex increasing the space assigned for research collections and alleviating a serious shortage of storage space for samples and other materials. Effective management has increased warehouse capacity, now filled to 82 percent of capacity; this represents a 1 percent decrease from last year's inventory and a 3 percent decrease over the past 2 years.

During August 1986, the William Dixon, Jr., family donated to the Geological Survey, through the Society for Illinois Scientific Surveys, a portable core trim saw. The saw has been place in the Rock Crushing Preparation Room at the Annex and is being used by staff and visitors for trim work on smaller hand samples and to prepare samples for Educational Extension rock and mineral kits. A Minolta Maxuum 7000 camera and a special area for photographing cores are now available at the Annex facility for visitors and Survey staff.

Environmental Geology Research and Service

During excavation of the earthen clay liner, fluorescein dye was found seeping from the liner. Beverly Herzog (left center) and Robert Griffin (right) are attempting to trace back the dye stains to determine the origin of the flow paths of dye; behind them, Wen-June Su examines a soil-water sampler. At far left, Mike Roulier of the U.S. EPA excavates a moisture-measuring instrument.

ENVIRONMENTAL GEOLOGY RESEARCH AND SERVICE PROGRAMS

The Environmental Geology Program provides basic geologic data (and interpretations of these data) that can help government, industry, and the public make informed decisions and take appropriate actions to protect and enhance the natural environment and develop the state's mineral resources in a responsible way.

Research and service elements of the program focus on locating and protecting groundwater resources, managing wastes, siting facilities in Illinois, monitoring lakes and rivers, studying natural and man-made geologic hazards (such as landslides, earthquakes, and mine subsidence) and suggesting ways to mitigate their effects, and conducting land-use planning studies.

Northern Illinois Office of the ISGS (Dixon, Adams, and Gross). The Survey opened a new office in August at the State of Illinois Center in the Chicago Loop to provide technical liaison with government and industry and furnish geologic information to the general public. To serve government agencies and firms involved in geotechnical engineering, waste disposal, drilling, and mineral development, the staff will provide geologic information, collect data (such as boring logs, rock cores, soil samples, photographs and reports), and review geologic portions of project studies. The office includes a library containing ISGS publications and maps, especially those pertaining to northeastern Illinois.

The office also serves the Superconducting Super Collider project by providing local contact with governmental bodies located in the area of the proposed SSC and with SSC for Illinois, Incorporated.

ENVIRONMENTAL STUDIES AND ASSESSMENT

The Environmental Studies and Assessment Unit was organized in 1984, and upgraded to a Section in 1986. It began the year with three families of grant- and contract-supported projects. One, the Lands Unsuitable for Mining Project (LUMP), was later transferred to the Computer Research and Service Section to form the core of that new section. The second, Long-Term Ecological Research (LTER), continues at a modest level. The third, Siting the Superconducting Super Collider (SSC) in Illinois, has grown to be a $2.2 million research effort involving several sections of the ISGS and all other divisions of the Department of Energy and Natural Resources (DENR).

The environmental studies and computer sections work closely in many projects, and have adjacent office space so they can efficiently share computer equipment. The Environmental Studies Section serves as the administrative link for the Chicago office of the ISGS.

Long-Term Ecological Research (LTER)

Long-Term Ecological Research (Gross, Cahill, M. Miller, Grubb, S. Miller, Holden, and others). The original 5-year grant from the U.S. National Science Foundation (NSF) expired January 15, 1987. A team from the three Surveys and Western Illinois University submitted renewal proposals to NSF this year, and funding was extended for a final 2-year period. The program emphasis during this period will be on publishing the field results of research conducted over the first five years.

Long-Term Resource Monitoring (Gross and McKay). The U.S. Army Corps of Engineers has begun a 10-year, $200 million Environmental Management Program (EMP) for the Upper Mississippi River, an area involving Illinois, Missouri, Iowa, Wisconsin, and Minnesota. Of the 1,171.2 miles of the Mississippi and Illinois Rivers in the Upper Mississippi drainage area, 907.7 miles (77.5%) is in or adjacent to the State of Illinois.

The EMP effort includes a construction component for habitat improvement projects and a research effort modeled after the LTER research program. EMP research components include Regional Trend Analysis (RTA), Problem Identification Analysis (PIA), and Intregrated Data Management System (IDMS) with a major Geographic Information System. Work plans are now being developed, and modest programs will begin in federal FY87. Gross is the State of Illinois representative to the IDMS Work Group. Julie Kellner of the Springfield DENR office serves as the liaison to all the work groups.

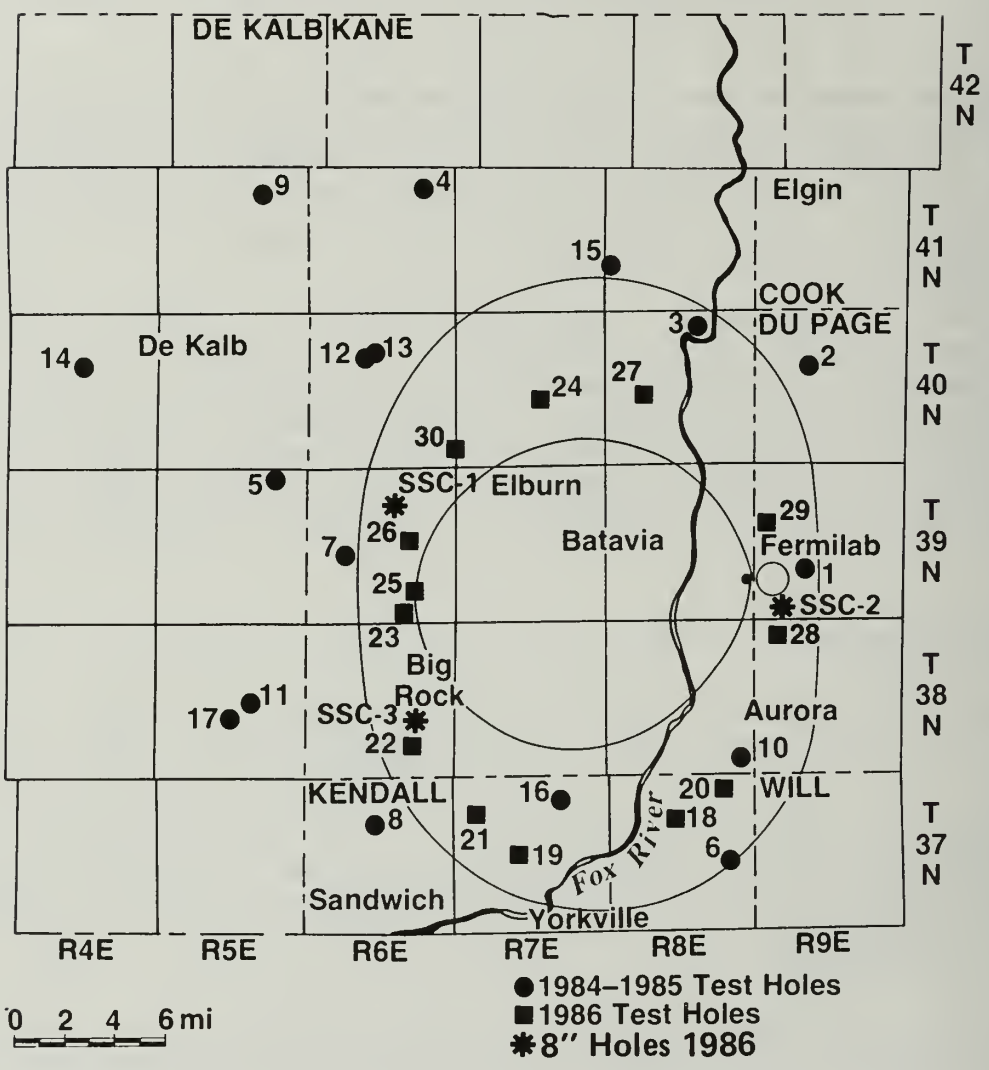
GEOLOGY-FOR-PLANNING

Siting the Superconducting Super Collider (SSC) in Illinois. The SSC project is receiving considerable national attention and is a top priority in the Department of Energy and Natural Resources (DENR). The SSC, a U.S. DOE-sponsored project, is to be a high-energy physics facility consisting of experimental areas and an elliptical tunnel (a ring) about 52 miles in circumference. The facility is being designed to study the basic nature of matter--the nature of particles resulting from the collision of protons travelling at nearly the speed of light. The protons will be guided by superconducting magnets in the tunnel.

The location of the SSC will be determined by competitive bidding among interested states. About three years ago Governor Thompson established a task force to attract the SSC to Illinois, and DENR was designated the lead agency. A Geological SSC team was set up within the ISGS; an Environmental SSC team involves all five divisions of ENR. Numerous projects have been undertaken to determine the most suitable Illinois site in terms of geologic, environmental, and economic considerations.

In April 1986, the Central Design Group of the Universities Research Association released a detailed design and cost estimate for constructing the SSC, which will be a $4.35 billion construction project. In December the Secretary of Energy announced his intention to recommend funding and construction of the SSC, and in January President Reagan announced his vigorous support. In February the DOE announced the schedule for siting and construction of the project.

1986 SSC Study Corridor and ISGS Test Drilling Site Locations



The State of Ilinois is ready for the formal siting process. The schedule: April 1987: DOE issues invitation for site proposals; August 1987: states submit proposals; September 1987: DOE refers qualified proposals to NAS/NAE; December 1987: NAS/NAE recommends best qualified sites; July 1988: DOE designates preferred site; January 1989: final site selected.

Illinois Proposal to DOE (Kempton, Gross, and many others). The U.S. DOE will issue a final call for proposals in April 1987. Illinois DENR, through the Illinois Institute of Technology Research Institute (IITRI), has prepared two complete drafts of the Illinois proposal to DOE. A third draft will be completed in May and the final proposal will be submitted in August. The highest priority now for the ISGS is to provide text and graphics input to that proposal and furnish reports, maps, and documents to be appended to the proposal.

Administration of SSC Projects (Gross, Kempton, Leighton, Cartwright, Hines, Lach, and others). John Kempton, Head of the SSC Geological Team, is overseeing the major drilling and seismic programs. Gross leads an SSC Environmental Team involving all five divisions of DENR, and is also a member of the executive committee of the SSC project. This project involves many departments of state government, several private contractors, many elements of county and local government, legal issues, federal laboratories, and considerable interaction with Washington, DC.

SSC Drilling Program (Kempton, Curry, Grease, Vaiden, Hannah, Schumacher, and Norton). The Geological Task Force concentrated on investigations of the area within the most likely corridor for the location of the SSC.

Thirteen test holes were drilled, cored, logged, and tested after suitable sites were located within the corridor. These 13 holes represent 6750.6 feet of drilling--an average of 518.5 feet per hole. Drilling began at the end of May and was completed at the end of December. Selected cores from both the drift and bedrock were packaged for laboratory testing, and all test holes were geophysically logged by ISGS personnel.

Under the supervision of R. A. Bauer, in-situ stress measurements were made in two holes (26, 28). Preliminary results, which verify stress measurements obtained elsewhere in the region, will be an important consideration in the design of the rock chambers for the SSC experimental areas.

To support a seismic reflection survey, three test holes (each 8 inches in diameter) were drilled below the St. Peter Sandstone by the Layne Western Company and logged by Schlumberger to obtain data for preparing synthetic seismograms. Additional logs were run to obtain data on rock properties and radioactivity background. The first 8-inch hole (SSC-1) on the north end of a proposed reflection line was drilled utilizing the dual-wall, reverse circulation drilling method to allow for collection of water samples for Radon gas analyses at selected intervals during drilling. The State Water Survey also used this hole for a pumping test of the St. Peter Sandstone. A down-hole TV camera recorded the wall characteristics in each hole, and three piezometers were set in each hole at the proposed tunnel level and 100 feet above and below that position. In hole SSC-2 at Fermilab, 80 feet of 4-inch core was taken to compare with rock mechanics data obtained from the NX wireline cores. The first hole was started in late September 1986 and all three were completed in mid-January 1987.

Seismic Refraction Survey in the Proposed Siting Region for the SSC (Gilkeson, Laymon, Padovani, Lin, Gendron, and Tindall). Seismic refraction methods were used to investigate geologic materials within a corridor above the proposed location for the SSC tunnel. Eighty line-miles of seismic data, gathered during the 1986 field program, are being processed to determine the thickness of glacial drift, the topography on the bedrock surface, and the character of the rocks at the bedrock surface. The data are being used to refine regional maps of the glacial drift thickness and bedrock surface topography. Refraction data will be used to determine the maximum depth of bedrock valleys in the proposed corridor. The depth of these valleys helps to define the optimum depth for tunnel construction. Depth to bedrock and glacial drift thickness also influence the location and construction of vertical service shafts that reach from land surface to the tunnel.

High-Resolution Seismic Profiling (Heigold). A test line of high-resolution CDP reflection profiling extending just over 3 miles along Daubermann Road north of Kaneville in Kane County, Illinois, has been run by Walker Geophysical Company of Issek, Iowa. The data reduction and interpretation phases are progressing, and a final report on the efficacy of this method for mapping stratigraphic interfaces at the SSC site is being prepared. Preliminary field examination of the seismic data indicates that this method provides the desired results and can be used on a larger scale project at some later time.

Natural Radioactivity Survey in the Proposed Siting Region for the SSC (R. Gilkeson, Cahill, Gendron, Padovani, Kulju, and Ramamurthi). A field program is being conducted to characterize the natural background radioactivity of geologic materials and groundwater in the proposed SSC region. Radioelement analyses were performed on rock samples that were collected from drill holes located in the proposed siting corridor. The analytical results are being compared to special radioactivity measurements made in the boreholes with electronic instruments.

Groundwater samples are being analyzed for dissolved concentrations of radon, radium, and uranium. Groundwater samples were collected from wells that produce groundwater from the strata that will be penetrated by tunnel construction. The measured concentrations of dissolved radon in these groundwater samples will be used to calculate the radon concentration that would be present in the natural atmosphere in a tunnel cut in these rocks. This information will be used in the design of mechanical ventilation systems for the tunnel.

Geotechnical Studies for SSC (Bauer, Hasek, and Su). Strength testing has been completed on the first 17 exploration holes. Currently, strength testing is being performed on the various types and fillings of joints encountered in the five geologic formations and on large-diameter core. In-situ horizontal and overburden stresses in two boreholes, one on each side of the proposed SSC ring, were successfully measured.

Geotechnical support for the SSC Project also includes characterization of montmorillonitic clay seams, shear strength of rock joints, measurements of thermal conductivity of rock samples, and development of computer hardware and software for the analysis of the data.

Data has been obtained on comparable tunneling projects, including the Chicago Tunnel and Reservoir Project (TARP) and the Milwaukee Water Pollution Abatement Program (MWPAP).

Environmental Atlas (Hines and 16 others). "Siting the Superconducting Super Collider in Northeastern Illinois: Environmental Screening Atlas" was released in February. The Atlas contains 41 maps that illustrate the data being used in the Geographic Information System computer modeling. This model will indicate the optimal location of the SSC with respect to environmental, cultural, and geotechnical constraints. The Atlas, which will be included in the State of Illinois proposal to U.S. Department of Energy, was produced by the ISGS in cooperation with the Natural History and Water Surveys and the State Museum.

Environmental Modeling Publication. A series of siting models is now being used on the DENR Geographic Information System to facilitate selection of the best possible site for the SSC and to demonstrate to the U.S. DOE that the State of Illinois has the data necessary to ensure successful siting. All five divisions of DENR are contributing to this publication to be issued by the Natural History Survey.

Disposal of Excavated Material from the Proposed Northeastern Illinois SSC (Curran). A linear programming (LP) model is being developed to estimate the transportation costs of various plans to use the material excavated from the proposed SSC tunnel. Because the transportation costs associated with disposal and utilization alternatives are expected to range from $3 to $5 million dollars, analyzing these costs for each alternative is of great economic importance. The supply constraints of the LP model include volume calculations (extrapolated to percent composition of glacial till, sand and gravel, shale, limestone, dolomite, and cherty dolomite) and distribution to the removal locations for the excavated material described under two removal plans. The demand constraints of the LP model assume disposal in abandoned gravel pits and rock quarries located within 5 miles of the proposed SSC ring. A pit and quarry inventory was made, using enlarged aerial photos (scale 1:6,000) taken in the spring of 1986; volume capacities are being calculated for each excavation.

The boundaries of the pits and quarries identified in the inventory were digitized and added to the Geographic Information System (GIS) database. Each pit and quarry was assigned an attribute consistent with the Land Use Data Analysis Program's (LUDA) classification system of the USGS, permitting the data to become part of the Illinois GIS model to optimize the location of the SSC ring.

Other Geology-For-Planning Projects

Geology for Planning Coal Mining in Perry County (Berggren, Danner, and McKay). This project is designed to provide geologic information for Perry County in a form useful for long-term coal mine planning, construction, and operation; for mining regulation; and for both private interests and public policy. In 1984 Perry County's six mines produced 15.0 million tons of coal--23 percent of the state's total production. Previous studies have reported 2,096 million tons of coal reserves.

Envisioned as the first in a series of similar county reports, this study will utilize the ENR Geographic Information System (GIS) for generating project maps. Field work and the results of limited test drilling are being incorporated into the maps. Efforts have been concentrated on Quaternary materials to provide stratigraphic control for the overburden studies. Design of the GIS work and of the final report is underway.

Geotechnical Site Investigation, 6 GeV Synchrotron X-ray Source, Argonne National Laboratory (Killey and others). Argonne National Laboratory has asked the Survey to study the geologic materials that will be involved in the construction of its $300 million 6 GeV Synchrotron X-ray Source. A preliminary proposal and budget submitted for review describe the scope of assistance to be rendered by the Survey in two basic areas: (1) characterization of the vibration-transmitting qualities of the geologic units to determine feasibility of designs to minimize vibration transfer, and (2) determination of standard geotechnical and geophysical parameters to assure stable and secure foundations for the positron storage ring.

Geologic Factors Related to Indoor Radon (R. Gilkeson, Cahill, and McFadden). Gilkeson and Cahill are co-chairmen of an ISGS Radon Studies Committee set up to study the geologic factors associated with indoor radon. The committee developed a comprehensive research program to investigate geologic factors that are important controls on indoor radon concentrations in Illinois. The research program was described in a proposal submitted to the Governor's Radon Task Force; the Final Report of the Radon Task Force recommended that the geologic studies described in the proposal be undertaken.

Other products of the Survey's Radon Studies Committee included preparation of three reports to the Radon Task Force: (1) a report on the significance of NURE aerorad data to the indoor radon issue, (2) a detailed study of NURE aerorad data in the Paducah Quadrangle region of southern Illinois, and (3) a report on radon activities by other states. The committee also provides counsel to the Department of Nuclear Safety (including field study of radium spoil contamination in the area of Ottawa, Illinois) and to the general public, including press interviews and meetings with the Northwest Municipal Conference (an alliance of communities in northeastern Illinois).

WASTE MANAGEMENT

Landfills/Groundwater Contamination

Earthen Liners: A Field Study of Transit Time (Cartwright, Albrecht, Brutcher, DuMontelle, Griffin, Herzog, Keefer, Krapac, Larson, K. Miller, Morse, Poole, Risatti, Stohr, and Su). Performance of a field-scale compacted earthen liner is being evaluated in a multiyear, U.S. EPA-funded project that began in late 1985. The project objectives are to (1) determine transit times for water flow and nonreactive solute transport through a partially saturated field-scale liner, and (2) test the accuracy and practicality of available methods for predicting transit times.

A small (10 x 30 x 3 ft) prototype version of the field-scale liner was constructed of local till to determine the best methods of instrumentation and to determine if the infiltration criteria could be met. As part of this con-

struction, the foundation for the full-scale (approximately 30 x 60 x 3 ft) liner and the structure to house it was laid and a mobile home obtained to serve as a field laboratory. Excavation of the prototype in December revealed that vertical and horizontal instruments performed equally well, that hydraulic conductivity requirements could be met, and that the interfaces between lifts of till formed preferential flow paths.

The prototype also provided samples for further testing of hydraulic, engineering, and chemical properties. Results of these tests will be used in the design of the field-scale liner, to be built this summer.

Geotechnical Support for Earthen Liner Project (Su, DuMontelle, and Stohr). Geotechnical support for the U.S. Environmental Protection Agency Earthen Liner Project was designed to assure proper selection of material and assist in the construction of a prototype of a full-scale liner. A quantitative geotechnical evaluation system was designed and used for liner material selection. This system, cited by the U.S. EPA for use in its national guidelines, will result in a more reasonable selection of borrow sites. Engineering geology quality control/assurance procedures used ASTM standard procedures and ISGS modified procedures.

Foundation site conditions were described and modified to accommodate the natural drainage conditions and minimize environmental impact. The site was surveyed before and after construction. The foundation was designed to address both hydraulic and geotechnical requirements. A layered foundation was constructed to interrupt groundwater capillary action. Bearing capacity of the foundation was sufficient to support a 50,000-pound vibrating compactor during the liner construction. Construction of the 10 x 20 x 3 foot liner was completed in time to complete hydraulic conductivity testing.

Groundwater Impact Assessment of Contaminant Migration Through Typical Surficial Geologic Sequences of Illinois (Hensel, Berg, and Griffin). The Illinois Pollution Control Board and the Hazardous Waste Research and Information Center (HWRIC) are funding a project which will assess the impact of contaminant migration through 14 different hydrogeological environments typical of Illinois. The migration of six contaminants will be digitally modeled with two landfill design scenarios for each hydrogeologic environment. This information will be used by the Pollution Control Board for the upcoming revision of state regulations concerning Subtitle D waste disposal sites.

Preliminary Groundwater Quality Assessment of a Selected Area in St. Clair and Madison Counties, Illinois (McKenna and J. Gilkeson; Shafer, State Water Survey). This study initiates a preliminary groundwater quality assessment in St. Clair and Madison Counties. Before wells are selected for sampling by the State Water Survey, the Geological Survey conducts a preliminary evaluation of the near-surface geology of the study area. The results of this study will be utilized in the design of a more thorough assessment to be completed in 1988.

Reassessment of Landfill Suitability Areas in McHenry County (A. Stecyk and Berg). The geologic suitability of areas in McHenry County for landfilling of municipal wastes was reevaluated from 1985 maps. Geologic information from several thousand new water wells was studied and used to reinterpret the geology and presence of permeable materials within 50 feet of the surface.

Approximately 27 percent of the 1975 landfill suitability maps was remapped to accommodate the new data. In general, there was an increase in sensitive areas in eastern McHenry County. This new information will aid county administrators in locating an acceptable sanitary landfill site within their county's boundary.

Environmental Effects of Oil Field Brines (Hensel, McKenna, Poole, Steele, Whitaker, E. Smith, Heigold, Laymon, and Cline; State Water and Natural History Surveys). The Department of Energy and Natural Resources has funded a reconnaissance study to assess the effects of past and present oil brine disposal practices on the water, soil, and biotic resources of southeastern Clay County. Since the occurrence of brine water may be either natural, or may result from disposal practices, the chemical composition of the brine has been analyzed to determine its sources. Ion ratios and salinity have been used to differentiate oil brine from shallow brine from fresh water.

Electrical Earth Resistivity, a geophysical technique, has been used to identify the extent and source of brine plumes at two filled-in brine holding ponds. This method is effective for tracing brine plumes because the highly saline brine-contaminated water has lower electrical resistance than does fresh water. Forty-one groundwater monitoring wells were installed at the two test sites to corroborate the findings of the resistivity survey. Chemical analysis on water from these wells yielded total dissolved solids concentrations of over 50,000 mg/L near the centers of the brine plumes.

As a final task, estimates have been made about the potential impacts of brines in other oil-producing counties in Illinois. Shallow aquifers in these areas are most susceptible to oil brine contamination because water quality may be affected by seepage from overlying brine ponds, potential leakage from brine injection wells, and/or upward migration through unsealed boreholes.

Hydrogeology of Two Sludge Application Sites in Winnebago County, Illinois (Berg and Morse). This 2-year study, conducted with inital funding from the Rockton Township Board of Supervisors, evaluated groundwater contamination caused by application of sewage sludge to agricultural land near Rockton. Data indicate that nitrate contamination exists beneath both application sites. However, data regarding contamination by metals, organics, chloride, MBAS, and nitrogen is inconclusive. Results suggest that sludge application onto these agricultural lands be reduced because of the sensitive sand and gravel terrain.

Geology and Hydrogeology of a Sewage Sludge Land Application Site in Northern Winnebago County (McKenna, Berg, Morse, and E. Smith). The Sanitary District of Rockford has funded a study of geology and groundwater flow at another site to determine the potential for contamination of groundwater by applications of dehydrated sewage sludge. Numerous drill holes show that the site contains about 100 feet of till overlain by loess; in some areas a thin sand underlies the loess. Although groundwater flow at the site is mostly downward, horizontal flow occurs in several directions. Additional work on this project will focus on groundwater and soil-water quality, determination of hydraulic conductivities, and assessments of the potential for contamination beneath plots receiving varying rates of sludge application.

Statewide Landfill Inventory (Dixon, Hensel, Mehnert, Brutcher, and Keefer). The Statewide Landfill Inventory, a computerized database describing all the known land-based waste disposal facilities in Illinois, was completed in June 1986. The inventory now provides information on the name, location, disposal method, and sources and types of wastes of 2,890 disposal sites.

Statewide Landfill Inventory Update (Mehnert and Keefer). This database is being updated with new information from county, regional, and state governments. Hazardous waste disposal updates are emphasized. Information from the Inventory is forwarded to all persons and governmental agencies requesting it.

Deep-Well Injection

An Assessment of Class V Injection Wells in Illinois (Hensel and E. Smith; State Water Survey). The Illinois Environmental Protection Agency has funded an investigation of the degree of risk associated with Class V underground injection activities in Illinois. Also assessed were criteria that should be considered by IEPA for regulation of these injection wells. Class V wells include those used for disposal of storm water runoff, agricultural runoff, nonhazardous wastes, and heat pump return flow into or above underground sources of drinking water. This investigation indicated that the first three types of wells may present a risk for contamination; however, heat pump return flow wells present little or no risk of contamination.

Evaluation of Current Underground Injection of Industrial Waste in Illinois (Brower, Hensel, and Krapac). This study, mandated by the Environmental Protection Act, January 1, 1985 and conducted jointly with the Water Survey, has determined that the regulations and regulatory practices governing deep-well injection of hazardous and nonhazardous industrial wastes are adequate and will ensure long-term protection of underground sources of drinking water, human health, and the environment. Existing requirements for siting, design and construction, operation, testing, and monitoring of Class I wells were concluded to be adequate and must be met before a permit to operate a disposal well is granted. A comparison of deep-well injection of industrial wastes with alternative disposal options shows that for certain types of hazardous wastes, deep-well injection is one of the less expensive disposal options and appears to have a less severe potential impact on the environment. An extensive review of the final draft report for the study has been carried out and the revised final report is nearing completion.

Investigation of the Hydraulic Effects of Deep-Well Injection of Industrial Wastes (Mehnert, Brower, and Gendron). A numerical model is being used to investigate the hydraulic effects of deep-well injection on the injection zone and its associated confining layers in the vicinity of the injection well. Geologic data already in ISGS files and data from extensive field investigations being conducted to hydrogeologically characterize the injection well system at an Illinois chemical plant will be used for the model.

Information generated from this project will indicate how adequate the current monitoring procedures are and provide vital information to the U.S. EPA, which must draft regulations for underground injection control. The U.S. EPA, the Office of Drinking Water, and the Illinois Hazardous Waste Research and Information Center are funding this project.

Ed Mehnert (left) and Ross Brower (right) look over a diagram of an injection well. Both have lead roles in studies of deep-well injection, a controversial method of waste disposal that has been used in Illinois since the mid-1960s.

Jim Risatti is studying microorganisms that may help to break down toxic organic compounds that often contaminate lake and harbor sediments, landfills, soils, and groundwater. Risatti works with an anaerobic hood because these bacteria are being cultured in a zero-oxygen atmosphere.

Hydrogeological and Hydrochemical Assessment of the Basal Paleozoic Units for Wastewater Injection and Confinement in Illinois (Brower, Gendron, Keefer, and A. Stecyk). This study is part of a regional project funded by the Underground Injection Control Practices Council and the U.S. EPA to assess the hydrogeology and hydrochemistry of the Mt. Simon Sandstone and its overlying confining units. The study is important because a significant number of disposal wells in the region inject hazardous wastes in this unit. Present federal regulations and state regulatory programs operating under primacy with the federal program require that Class I disposal wells be sited where the geologic conditions in the disposal zone and its confining strata will ensure protection for all overlying underground sources of drinking water.

Underground Injection Control Class I Service Program (Brower, Mehnert, Evans, and C. Wegscheid). Staff from the Geological and Water Surveys are continuing to provide technical consultation to the IEPA in its Underground Injection Control (UIC) Class I program. This regulatory program covers nine existing disposal wells at seven industrial sites in the state, and under the regulatory program all existing Class I wells in Illinois must be repermitted. Technical consultation, technical review of documents, and on-site observations have been given during the preparation of new permits. On-site work includes conducting inspection of surface facilities, observing and evaluating mechanical integrity testing and well work-overs, and reviewing regularly submitted operational monitoring data. A computer database is being set up to handle regularly submitted data from monitored parameters for each disposal well. Survey staff have responded to about 70 inquiries concerning this method of waste disposal.

Hazardous Toxic Wastes

Geochemical Interactions of Hazardous Wastes with Geological Formations (Roy, Krapac, Mravik, Dickerson, and Griffin). The U.S. EPA and the Hazardous Waste Research and Information Center are supporting this study of the physical and chemical interactions of hazardous liquid wastes with rock formations and associated brines that might be used for deep-well injection disposal. Studies conducted at 298°K and 100 KPa-pressure with a highly alkaline process water resulting from the manufacturer of pesticides indicate that the process water did not react to any significant degree with disaggregated samples of the Mt. Simon Sandstone, Potosi Dolomite, or Eau Claire Formation, formations used as disposal zones in Illinois. Some silica dissolved, reaching a steady-state concentration in about 10 days, but no gas evolution was detected. When mixed with the Mt. Simon Sandstone under the same experimental conditions, an oxidized, acidic liquid waste (pH2) became more basic and less oxidizing after 12 days of exposure, and resulted in minor CO_2 evolution. Similar studies at 313°K and 6000 KPa-pressure are currently being conducted. Study findings could provide data useful in developing standardized tests that would predict and test reactions expected to occur when a particular type of waste is injected at a specific site.

Clay Minerals and Their Role in Waste Isolation (Hughes, Warren, S.-F. Chou, Krapac, Roy, and Griffin). The goal of this project, partly an outgrowth of earlier studies on waste isolation at Wilsonville and Sheffield, Illinois, is to compare Illinois earth materials with those from other states to determine their suitability as waste absorbents or barriers. The research is also aimed at combining suitability studies with the near-surface and

aquifer maps of the state to provide guidance in the selection of sites for waste generation, storage, transportation, and disposal. For example, such information could provide a starting point for siting the federally mandated low-level nuclear waste disposal facility to be built in Illinois. A further goal is to determine which wastes, if any, cause clay liners to leak, and whether immiscible organic wastes adsorbed on olephyllic (non-wetting) clays are removed by percolating water. A 3-year proposal to expand this project has recently been submitted to the Illinois Hazardous Waste Research and Information Center.

Rates of Microbial Polychlorinate Biphenyl (PCB) Dechlorination in Anaerobic Sediments from Waukegan Harbor (Risatti, Sheridan, Ross, and Henebey). Industrial drainage into the harbor at Waukegan, Illinois has caused exceedingly high accumulation of polychlorinate biphenyls (PCBs) in the harbor sediments. A study is being conducted to assess PCB concentrations in these sediments and to evaluate the clean-up potential of anerobic degradation of PBCs by microbes.

To determine current levels of PCBs in the harbor sediments, core and grab samples were collected from 25 sites throughout the harbor; an additional 10 core samples were collected, using strict anaerobic techniques, and placed into jars under a nitrogen atmosphere.

PCB levels in Waukegan Harbor sediments ranged from about 5 ppm near the harbor entrance to greater than 17,000 ppm in slip 3. Although considered inordinately high, these levels are less than previously reported by other investigators.

To evaluate rates of anaerobic microbial activity in undisturbed sediments, anaerobic samples were refrigerated at 4°C and monitored for methane production. Slurries were also prepared from anaerobic sediments, and aliquots were dispensed into serum bottles to follow methane production. Degradation experiments were prepared with sediments from three stations, and parallel sets were incubated at 8° and 23°C for time periods of 1, 3, 5, 9, and 12 months. The PCBs in sediments from these cultures, from two stations, have been extracted and analyzed by gas chromatography, using electron capture and ion trap detectors. Several samples must still be evaluated before it can be reported whether or not PCBs are being anaerobically degraded in Waukegan Harbor.

An Assessment of the Environmental Hazard Associated with the Contamination of Lake Calumet, Chicago, Cook County, Illinois (Risatti, Sheridan, Courtney, Ross, Henebey, and Garrison). The area surrounding Lake Calumet has received a wide variety of liquid and solid wastes for over a century. Recent studies of very limited scope have reported elevated levels of heavy metals, arsenic, phenols, and organic compounds such as polychlorinated biphenyls (PCBs) and polyaromatic hydrocarbons in sediments and marsh soils of the area. The degree and extent of this contamination is unknown, and no systematic documentation exists concerning groundwater contamination. A cooperative study involving the ISGS, INHS, and HWRIC will combine intensive sampling and chemical analysis with a series of three toxicity tests to give the first reasonably complete picture of the environmental hazards associated with Lake Calumet. To date, 14 grab samples have been collected from the lake. Sediments have been analyzed for total organic carbon and for cadmium, copper,

lead, nickel, and zinc. Distribution patterns indicate that a drainage canal discharging into the lake near 118th Street is a major source of lead and zinc input to Lake Calumet. Studies determining the extent of microbial activity are currently underway.

Anaerobic microbial degradation of aromatic hydrocarbons has been suggested as a possible mechanism for long-term detoxification, and recently, evidence was presented for microbial dechlorination of PCBs in upper Hudson River sediments that had historically received large amounts of Aroclor 1242/1016. At the ISGS, attempts are being made to isolate organisms responsible for degradation and to measure rates of degradation under controlled laboratory conditions.

Evaluation of Groundwater Monitoring Programs at Hazardous Waste Disposal Facilities in Illinois (Herzog, Hensel, Mehnert, and J. Miller). This study of groundwater quality in Illinois, mandated under HB 3193, evaluates the ability of groundwater monitoring programs at hazardous waste disposal facilities to determine the effects of the facility on groundwater quality. Ten facilities around the state were chosen for detailed evaluation in Bureau, Cook, Crawford, Lawrence, Macoupin, Madison, Peoria, Will, and Winnebago Counties.

The study revealed a dramatic improvement in the quantity and quality of groundwater monitoring at hazardous waste disposal facilities in Illinois over the past 10 years. Six major conclusions resulted from this study: (1) thorough hydrogeologic studies are necessary before adequate monitoring programs can be established; (2) design of groundwater programs should consider individual site characteristics; (3) additional research is needed on monitoring well construction and on optimal well spacing; (4) accurate record keeping is essential for determining the adequacy of monitoring and changes in water quality; (5) greater use should be made of geophysics and computer modeling to aid in the determination of well locations; and (6) additional attention should be paid to on-site waste disposal and generators of hazardous waste.

Investigation of Industrial Chemical Pollution of Groundwater at Wilsonville, Illinois (Griffin, Herzog, Stohr, Hughes, and Glass). A final report of this investigation, completed last year, is now being prepared. Monitoring of the more than 40 wells installed on the site is continuing, providing a useful field laboratory for continued investigations of the mechanisms of migration of organic constitutents.

Low-Level Radioactive Waste

Methodology for Siting and Characterizing a Low-Level Radioactive Waste Disposal Facility in Illinois: Geologic and Hydrologic Factors (Berg and J. Miller; Wehrmann and Shafer, ISWS). This report, the third in a series prepared by the ISGS and ISWS for the Illinois Department of Nuclear Safety (IDNS), outlines a methodological approach for siting a low-level radioactive waste (LLRW) disposal facility in Illinois, emphasizing only geologic and hydrologic considerations. Special emphasis is given to geomorphic site characterization, design of drilling and monitoring programs, and determination of hydrologic factors. The first two reports dealt with regional aquifer conditions and with regional and site-specific hydrogeological factors critical to siting a low-level radioactive waste facility.

Geologic and Hydrologic Factors for Siting Hazardous and Low-Level Radioactive Waste Disposal Facility in Illinois: (Berg and J. Miller; Wehrman and Shafer, ISWS). This report is a compilation of all the data on low-level radioactive waste siting contained in three separate reports submitted previously to the Illinois Department of Nuclear Safety. Also included is information on hazardous wastes. This study emphasizes the importance of geologic and hydrologic criteria with regard to site performance, describes methods of investigation for site selection and characterization, and gives prohibitive recommendations for siting. The report describes four steps involved in screening procedures for site selection: regional exclusionary screening eliminates areas automatically based on the presence of certain factors; regional directive screening directs siting to favorable areas; site screening involves the collection of geologic and hydrogeologic data in the vicinity of the site to determine possible fatal flaws prior to site characterization; and site characterization describes the site in detail.

Study of Trench Covers to Minimize Infiltration at Waste-Disposal Sites (Cartwright, Larson, Keefer, Moffett, and Albrecht). A final report was submitted to the U.S. Nuclear Regulatory Commission (NRC) in October 1986 for this project, a multi-year study of trench cover designs. The study was initiated in October 1980 because of concerns related to the leakage of low-level radioactive wastes at the Sheffield disposal site. Several designs of layered-soil covers were tested through laboratory, computer, and field simulations. The layered covers varied in their ability to impede infiltration, but all limited infiltration more than did a typical cover.

Waste Disposal Service Activities

Landfill Reports (Herzog, McFadden, Hensel, Mehnert, Keefer, Poole, and Morse). During this reporting period, ISGS staff prepared 35 letters reporting on the hydrogeologic suitability of 79 proposed or existing waste disposal facilities. These reports required compilation and interpretation of all available surface and subsurface geologic information and in some cases required a field survey by an ISGS staff member. Those requesting this service included the Illinois Environmental Protection Agency, the Illinois Department of Nuclear Safety, the Illinois Attorney General's Office, county and municipal governments and planning agencies, consultants, site owners, environmental groups, and private individuals. One report involves a review of a remedial action plan for 32 sites in the Crab Orchard Wildlife Refuge. The counties involved were Champaign, Cook, DuPage, Franklin, Iroquois, Jasper, Jefferson, Kane, Livingston, Logan, Macoupin, Marion, Massac, McHenry, McLean, Menard, Peoria, Randolph, Saline, Stephenson, Vermilion, Wayne, and Williamson. In addition, numerous requests for information on various aspects of solid waste disposal were handled by phone and by consultations with visitors.

GEOLOGICAL STUDIES OF ILLINOIS LAKES AND RIVERS

Lake Michigan Research and Service

New record high lake levels, storm impacts, and land flooding have created great demand for ISGS technical data and services. The ISGS provided shore communities and other governmental agencies with data, maps, photos, site visits and conferences, and made more than a dozen presentations to civic

groups such as the North Shore Mayors' Lake Michigan Shore Council, the Rogers Park Condominium Owners Association, and the North Shore Board of Realtors. The ISGS is represented on the Chicago Shoreline Protection Commission and the City Club of Chicago Lake Michigan Task Force. Radio, television, and press coverage was unprecedented: Collinson participated in television programs, 10 radio interviews, and some two dozen press interviews, and was quoted in several periodicals, including the Time Magazine, U.S. News and World Report, and Chicago Magazine.

A senior scientist will join the ISGS in June to work on the Lake Michigan Program and on lakes and rivers research. Supporting ISGS efforts on Lake Michigan are ENR, the Joyce Foundation, Federal Fish and Wildlife Service, Illinois Division of Water Resources and the U.S. Corps of Engineers.

The Role of Silurian Bedrock "Reefs" in the Lake Michigan Trout Fishery (Holm, Collinson, L. Smith, Horns, and Norby). A request for federal assistance through the Illinois Department of Conservation resulted in the funding of a 1-year study of Julian's and Wilmette Reefs to determine the substrate type and potential locations for planting lake trout. In July, at ISGS request, the Great Lakes Fishery Laboratory made two side-scan sonar transects across Julian's Reef that showed several areas with small to large dolomite rubble (50-700 mm). In September, the University of Wisconsin's underwater video camera was used to make a videotape along these transects. The videotape coverage of more than 3 miles of transects showed that much of Julian's Reef consists of highly fractured, solution-pitted dolomite bedrock. Locally derived cobbles (50-250 mm) occur on the "reef" slopes. In November, scuba divers, while checking fish egg traps, recovered a few pieces of dolomite bedrock for physical description. The fractured bedrock and cobble-covered areas are attractive spawning grounds for lake trout.

Northpoint Marina Hydrographic Mapping Project (Norby, L. Smith, Shaw, and Pleibel). A contract mapping project completed in May produced five hydrographic maps (1:600 scale) showing 1985 culture, shoreline recession lines for 1985 and May 1986, and bathymetric contours and profile lines for May 1986. This information will be used by engineers in the construction of a new harbor in the Winthrop Harbor-Zion area.

Aerial and Land Reconnaissance of the Lake Michigan Shore (Norby, L. Smith, Collinson, and Shaw). Aerial photographic flights were made in March, June, and September of 1986 and February and March of 1987. Several land photographic trips were made during the year to photograph shoreline and revetment conditions in the Edgewater and Rogers Park areas of Chicago and the Wilmette, Lake Forest, and Winnetka areas of the north shore. These photographs have great value in ISGS responses to shore communities, individuals, and agencies on shore conditions. More than 3,500 35-mm slides were acquired during the year, and more than 600 slides were distributed. In addition, several dozen color prints from slides were distributed to home owners, contractors, attorneys, realtors, and governmental organizations.

This monitoring program has been expanded to include the entire shoreline from the Wisconsin to Indiana state lines. More frequent photographic flights are being made during this critical period of higher lake levels to monitor structure damage and erosion. The recent acquisition of an automatic camera that can handle long rolls of bulk film will increase efficiency.

Response to Lake Michigan Shore Erosion (Collinson, Holm, L. Smith, and S. Adams). Supported by the ENR Environmental Research Fund in 1986, this project has produced a computer inventory of 563 shore parcels that records locations, stabilities, shore protection, and in some cases, protection costs. In addition, a 48-page address list of riparian owners was compiled. The file has been used to update parts of the ISGS Coastal Atlas. The February 10, 1987 aerial photos are being used in a review of all elements of the program. The review will be completed by summer.

Damage and Shoreline Planning Survey: Response to Lake Michigan Storm of February 8, 1987 (Collinson, Shaw, and others). Funded by ENR, this survey will study damage effects, new shoreline positions, nearshore depths, and lake bottom sediment distribution and characteristics. Modern and historical photographs and engineering records will be acquired. The major phase of this study will be completed in early fall.

Development of a Beach and Shore Stabilization Demonstration Program for Use of Coarse Materials (Collinson, Chrzastowski, Shaw, and others). Sponsored by Illinois Division of Water Resources, this project will result in production of a demonstration program by late fall.

Littoral Drift Budgets for the Illinois Lake Michigan Shore (Collinson, Chrzastowski, Shaw, and others). The Illinois Division of Water Resources has funded a long-term cooperative study of littoral drift systems, which will continue into 1989.

Characteristics of Harbor Mouth Dredge Materials in Lake Michigan (Collinson, Chrzastowski, Risatti, and others). The Illinois EPA has blocked dredging of the harbor mouth at Waukegan because of inadequate study of pollution there. The ISGS has made previous studies of sediments in the harbor mouth and is proposing a study to be sponsored by the Illinois Division of Water Resources for sampling, sediment analysis, and chemical analysis.

Shore Damage and Mitigation Estimates for the Illinois Lake Michigan Shore (Collinson, Chrzastowski, Shaw, and others). Begun as a small project for the Corps of Engineers, this effort will continue into 1988 in order to revise high water estimates. Computer files, including descriptions of shore properties and shore protection construction costs, were sent to the Chicago District office in March.

Great Lakes Lake Trout Inventory (Holm and Morgan). Funding from the Great Lakes Fishery Commission will support compilation of a computerized listing of all lake trout research on the Great Lakes. The project, which runs from February 1, 1987 to July 31, 1987, will assist the Great Lakes Fishery Commission in defining and coordinating its management efforts for lake trout.

Lake Michigan Research Information Database (Holm, Jann, Morgan, and Brutcher). A grant obtained from the Joyce Foundation, Chicago, Illinois, will permit work to continue from November 1986 to October 1987 on the list of research projects and bibliography on Lake Michigan, currently being updated and edited. The bibliography has grown to more than 5,000 entries. The project listing includes 280 Lake Michigan research projects. Numerous requests from researchers and agencies for information on Lake Michigan have been answered.

Services to Shoreline Residents and Communities

Village of Wilmette Park District (Collinson). Site visits were made to Langdon Park at the request of the head of the park district, and telephone conferences also were held with NIPC regarding Langdon Park. Site visits and telephone conferences were made regarding protection at private sites on East Michigan south of Langdon Park. Numerous phone conferences were made regarding riprap and offshore breakwaters at condominiums in north Wilmette.

East Michigan Avenue Association Wilmette (Collinson). Site visits and photographs were taken in July and August. A conference and lecture were given in February, a site visit made, and color photos distributed.

Association of Sheridan Condominium (Collinson). In October and November, conferences were held with the Sheridan Condominium Owners Association. A lecture was given to the Rogers Park Association on shore protection methods.

Chicago District Corps of Engineers (Collinson, Norby, Shaw, and L. Smith). Slides, color prints, black and white prints, a computer file, and estimates of lake shore damage were provided to the Corps of Engineers.

Village of Glencoe (Collinson). At the request of the mayor, property near Glencoe Park was evaluated and depth maps for north Glencoe were provided. A dike used to protect the Glencoe Water Plant was evaluated.

Chicago Park District (Collinson). A set of aerial photos and shore depth maps was provided, and three conferences were held.

Edgewater-Rogers Park Site Specific Inventory (Collinson, L. Smith, and Shaw). A comprehensive site inventory of northern Chicago's shoreline, supported by ground and aerial photos, along with nearshore hydrography, was conducted in the spring of 1986. A report discussing the results of this study was prepared and forwarded to the Corps of Engineers in Chicago. This ongoing study is an open file report at the ISGS.

River and Backwater Lake Research

Geomorphology of the DesPlaines River Wetlands Area (Berg, M. Miller, and Holden). This study, initiated in 1985 and continuing through 1987, is determining the stability of the river channel along a reach of the DesPlaines River in Lake County, where an artificial wetland is being constructed. Twenty-nine surveyed cross sections were established along the river. Water depths and bottom samples were taken along each cross section to evaluate changes that occurred between the summer and late autumn 1986. Additional work at the site involved the construction of piezometers and periodic measuring of water-level elevations in order to determine shallow groundwater flow and groundwater-surface water interactions. This work was funded by the U.S. Fish and Wildlife Service through Wetlands Research, Incorporated.

Kankakee River Sandbody Evaluation (M. Miller, Berg, Holden, and Hindman). Local citizens perceived an increase in the amount of sand in the Kankakee River and interference with boat passage. A study was begun in the fall to compare present conditions with conditions documented in ISGS Environ-

mental Geology Notes 92 (Geology of the Kankakee River System in Kankakee County, Illinois) to determine whether the volume of sand in the river bed has increased during the last 6 years. Field data were obtained in August and September. The same methods and cross sections used in the previous study were used and the data was reduced to sand-depth point data. The Kankakee River, from the Indiana line to the city of Kankakee, has been digitized from USGS quadrangle maps, then plotted at twice the scale to provide a template for contouring the sand thickness data. Contours from the interpretation of the 1986 data will be digitized. Calculations of sand volume will be made with the GIS software, and results compared to the data obtained in 1978/79.

Geology of the Illinois-Michigan Canal National Heritage Corridor. Begun early in 1985, this National Park Service project has produced a 157-page geologic reference book (L. Smith and Collinson) for the Canal Commission and a color brochure about the Ice Age heritage of the canal area (Hansel, L. Smith, and S. Stecyk). The volume and brochure are being published by the Commission by midyear 1987.

HYDROGEOLOGY INVESTIGATIONS

Groundwater Protection

Groundwater Protection Program Plan (Berg, Cartwright, and Griffin; Shafer, ISWS). The State's Comprehensive Groundwater Protection Program, a major new program now in the planning stage, is being developed through the efforts of the Groundwater Protection Task Force set up by Governor Thompson. The Task Force helped to draft legislation that will implement the plan. Major elements of the plan include identification of resources, assessment of contamination, and development of an automated groundwater database.

A statewide groundwater assessment will be conducted and a long-term groundwater monitoring network and database system will be established. The assessment program will focus on locating all groundwater resources in the state, analyzing the hydrogeologic properties of the materials, and developing a baseline for measuring actual and potential contamination of the resource. The monitoring program will include locating and/or constructing designated wells for groundwater monitoring, and developing field and laboratory protocols necessary for analyses of the groundwater.

The program plans call for evaluating groundwater resources in several counties each year in order to assess all 102 counties in a 15-year period. Operations are to consist of on-going monitoring, sample collection, technical assistance, data analyses, and preparation of reports.

Occurrence of Agricultural Chemicals in Groundwater in Mason County (McKenna, J. Chou, J. Gilkeson, and Valkenburg; LeSeur, ISWS). This study is a continuation of the preliminary assessment of pesticides in soil and groundwater, in which trace levels of several currently used herbicides and two chlorinated hydrocarbon insecticides were found. The current study is attempting to determine if there are variations over time in the levels of pesticides present and if the pesticides are being transported deeper into the aquifer. Data acquired in this study will provide additional information on the persistence and mobility of pesticides in coarse-grained soils and allow for a more accurate evaluation of public health risks.

Persistence and Mobility of Selected Pesticides in Loessial Soils of Illinois (McKenna, J. Chou, M. Miller, Roy, Morse, and Valkenburg, ISGS; and Bicki, University of Illinois). This study will improve our ability to predict the transport and persistence of widely used agricultural pesticides in soils that are representative of soil and geologic conditions in Illinois. Recent studies suggest that infiltration of pesticides to groundwater may be more rapid than previously thought due to perferential flow along structural boundaries in fine-grained soils. If these findings are confirmed, changes in target area selection of criteria for statewide groundwater monitoring programs may be necessary.

Groundwater Geology

Groundwater Characterization of the Rockford Area (S. Stecyk and Berg). The ISGS and ISWS were contacted by the Hazardous Waste Research and Information Center (HWRIC) to characterize groundwater conditions in the Rockford area. The ISGS mapped in detail the subsurface drift within the Rock River Valley near Rockford and determined the position of the aquifer in which wells were finished. Four cross sections were constructed through the area, each showing the continuity of sands and gravels and low-permeability lacustrine and till units. This exercise was important to the project because the quality of groundwater within sands and gravels can be different above and below low-permeability units. This report will be published by HWRIC.

Assessment of Regional Groundwater Resources in Kankakee and Northern Iroquois Counties (McKenna, E. Smith, Keefer, and Dey; Collins, ISWS). The ISGS and ISWS are assessing the groundwater resource in the study area and evaluating the effects of increased agricultural irrigation on domestic water supply wells. The ISGS is providing information about the distribution and thickness of the geologic materials above the bedrock.

Groundwater Resource Assessment in Northern Illinois (R. Gilkeson, McFadden, Skinner, Stanke, and A. Stecyk; ISWS staff). Supported with Aquifer Assessment funds from the Department of Energy and Natural Resources, this new program involves a rigorous review of our statewide database for groundwater resources. The program is a 2-year investigation in the northern 35 counties of Illinois--the region in which approximately 100 public water supplies exceed the U.S. EPA drinking water standards for radium and barium. The high concentrations occur naturally in deep bedrock aquifers. The primary task is to gather information about shallow groundwater resources that have very low dissolved concentations of radium and barium.

The first year of the program is concentrated in the northeastern counties, where information on shallow groundwater resources is also needed because of regional development. County governments are being invited to participate in the program by providing county records and personnel to verify the location of well records. DuPage, Kane, Lake, and McHenry Counties are participating in the effort. A statistical study of the accuracy of well locations submitted by drillers determined that the locations are highly inaccurate and that an on-going well-location verification program is essential when drillers' records are used as geologic information for regional groundwater resource assessments.

Location of Gassy Aquifers in Illinois (Riley). Beginning in the late 1960s a field study was initiated to investigate the occurrence of natural gas in fresh water wells in Illinois. About 1,400 tests were conducted on water wells in virtually every county. The information collected consists of well data, natural gas analysis, and the approximate quantity of gas in the water. These reports are being entered into a computer database and will be used to generate a map showing the locations of gassy aquifers that have been tested. This map will help water well drillers minimize the danger of drilling into a potential natural gas source.

Groundwater-Geophysical Studies

Renewable Energy Resources of Illinois (Larson). The Geological Survey, the Water Survey, and the Natural History Survey conducted a 2-year Board-funded investigation of the renewable energy resources of Illinois, giving particular attention to one type of geothermal system, the geothermal heat pump. Heat pumps are being installed in Illinois for domestic and light-duty industrial space heating and air conditioning; however, the basic thermal properties for Illinois soils are not known. Soil samples have been collected from across the state and analyzed for their thermal properties. The results were incorporated into the statewide Geographic Information System so that maps can be prepared to show the range of thermal properties of soils in Illinois. A final report and maps were submitted in September 1986.

Groundwater Resources in Kane County (R. Gilkeson, Laymon, McFadden, Padovani, Skinner, and A. Stecyk; ISWS staff). This thorough study of groundwater resources in the glacial drift and shallow dolomite bedrock of Kane County is supported by funds from the county and local municipalities and from the Division of Water Resources of the Illinois Department of Transportation. The regional program's successful identification of aquifers with large-potential groundwater supplies has encouraged several communities to make separate contracts with the Geological and Water Surveys to improve local development of the groundwater resources. Contracting communities include Aurora, Batavia, Geneva, and Montgomery. A proposal to conduct a similar study has been submitted to the city of St. Charles. These new contracts are significant because they involve the design of sophisticated aquifer tests to evaluate regional productivity of the shallow aquifers. To date, aquifer tests have been performed at Aurora, Geneva, and Montgomery. Additional tests are being designed for these three communities and also for the communities of Batavia, St. Charles, Elburn, and Hampshire. Surface geophysical methods are playing an invaluable role in the design of these tests and in the overall assessment of the regional groundwater resource.

Groundwater Service Activities

Water Use Act Activities (McKenna, E. Smith, J. Gilkeson, and Mushrush; Olson, ISWS staff). Under the provisions of the Water Use Act of 1983, the Geological and Water Surveys provide technical support to county soil and water conservation districts in estimating the effects of proposed high-capacity wells on groundwater resources. In 1986, Survey staff evaluated the hydrogeologic conditions in the vicinities of 62 proposed wells. Staff have also reviewed proposed water use legislation and are currently developing a slide/tape presentation about groundwater for soil and water conservation districts.

Definition of a Linear Sand and Gravel Aquifer Near Stolletown, Clinton County, Illinois (P. Reed). Surface geoelectrical studies have proven useful in defining aquifers in Illinois where groundwater supplies are marginal for municipal and farm use. Prior to the Survey's resistivity survey, six unsuccessful test holes had been drilled by the district. Using information from the ISGS resistivity survey, the district sited three observation wells and one test well capable of yielding 200 gallons per minute.

Groundwater Data System (Mushrush and McKenna). To date, 7,419 records have been entered into the Groundwater Data System. These records represent all Water Use requests, groundwater possibility reports, and electrical earth resistivity studies done in the Groundwater Section since 1970. Information stored in this system can be retrieved by well location, depth, use, and target aquifer. Menu-driven programs provide accessibility and maintenance of the database. An integral part of maintaining the file is the recording of each request for service work as it is received.

Illinois Irrigation Association Meeting and Midwest Water Well Exposition (P. Reed, Brower, and E. Smith). Groundwater Section staff from the Geological and State Water Surveys manned a booth display at the annual IIA Meeting in Springfield. The exhibits focused on the Water Use Act and joint research in irrigation potential in Illinois. Survey research programs and service aimed at developing and safeguarding groundwater were discussed with well drillers, irrigators, and other attendees.

Groundwater Geology Reports and Electrical Earth Resistivity Surveys (Staff). Letter reports on groundwater geologic conditions are prepared at the request of citizens, industry, public water supply systems, and governmental agencies to help site and develop water supply wells. Electrical earth resistivity (EER) surveys are conducted where test wells have failed to obtain an adequate water supply. The EER surveys supplement the information summarized in the geologic report. In addition, numerous requests for general geologic information are answered.

During 1986-87, 308 letters, reports, and technical letters were prepared, 1,130 telephone requests handled, and queries from 96 visitors answered.

Groundwater Possibilities Reports		91
Public water supplies	15	
Farms and rural residences	71	
Irrigation	11	
Industrial	10	
Electrical Earth Resistivity (EER) Surveys		48
(Reed, Masters, Smith)		
Municipal supply	7	
Industrial supply	4	
Pollution studies	2	
Farms and acreages	34	
Research	1	

Dan Barkley uses total station survey equipment for precision measurement of horizontal and vertical positions of monuments over a high-extraction retreat coal mine; this project is part of the Illinois Mine Subsidence Research Program.

Demand for Survey expertise and data on Lake Michigan increased during the year as lake levels reached new highs and waves battered the shoreline.

Borehole Logs (includes other studies)		36 sites (112 logs)
(Black, Danner, Laymon, McFadden, Reed)		
Density and porosity evaluation	23	
Relating EER to lithology	4	
Aquifer evaluation	9	
USGS-ISGS COGEOMAP	14	
SSC project	72	
General Technical Information		112
Miscellaneous Letters		21
Sieve analysis of well cuttings	11	
Study of samples from problem wells	6	
Specimen identification	4	

EARTH HAZARDS AND ENGINEERING GEOLOGY

Landslides Studies

Landslide in Iroquois County (Bradford, Killey, and Krumm). Continuing research to determine failure mechanisms at a landslide along Sugar Creek has included further drilling to test the suspected plane of failure.

Clay Mineral Studies Related to Earth Hazards and Engineering Geology (Warren, Bradford, Killey, and Hughes). These studies are designed to ascertain the role of clay minerals and clay-size nonclay particles in landslides, slumps, building foundation failures, road-base movements, roof falls and floor "squeezes" in coal mines, and similar phenomena. The work is part of an investigation of landslides in and around Chester, Illinois, designed to identify former landslides, monitor active slide areas, discover the cause of the slides, predict future problem areas, and suggest appropriate remedial action.

Landslide in Vermilion County (P. Reed, Follmer, Bradford, and Gefell). Staff members provided assistance in interpreting a slope failure at the H & L landfill near Danville. An earlier geophysical study by P. Reed was helpful in defining the location of a subsurface tunnel at the landfill.

Mine Subsidence Research

Illinois Mine Subsidence Research Program (DuMontelle, Bauer, Gefell, Barkley, and Trent). The Illinois Mine Subsidence Research Program was initiated in 1985. A 5-year Memorandum of Agreement signed this year by the State of Illinois and the U.S. Bureau of Mines provides that ISGS and the Twin Cities Research Center of the USBM cooperate and collaborate on mine subsidence-related research. The major emphasis of the Illinois Mine Subsidence Research Program is on developing guidelines that will maximize coal production while mitigating the effects of subsidence in areas of prime farmland.

Work has been completed by Robert Darmondy of the University of Illinois Agronomy Department for this year's measurement of crop production over high

extraction coal mines in Illinois. Paul Chugh of Southern Illinois University has completed work on the investigation of floor stability in one of two mines for this fiscal year. Instrumentation is complete at a study site over a planned subsidence high-extraction retreat mine in Williamson County and initial surveying has begun. A proposal by the Survey accepted by the USBM provides for 3.5 years of funding to cover installation and monitoring of instrumentation over two additional panels that will experience subsidence.

The ISGS is negotiating with coal companies to select new investigation sites over high extraction active mines and is supervising installation and monitoring of instruments at the new sites.

Time Domain Reflectometry research, sponsored by the U.S. Office of Surface Mining, is designed to investigate a simple way to monitor subsidence movements in bedrock. Coaxial cables were grouted into boreholes over a panel that will soon subside. Baseline measurements have been made of the cables before the onset of subsidence, and subsidence is expected to impact the first cable in a few months.

Computer-Assisted Directory of Mine Subsidence Insurance Claims (Bradford, DuMontelle, Hindman, Schwartz, L. Cooper, and Junkins). The Illinois Mine Subsidence Insurance Fund (IMSIF) renewed support for the database until June 1987. Efforts are underway to make the database more automated and maintnance free.

Automating the database included purchasing a 40MB AT clone to speed up processing time and to establish better communications with computers at the Insurance Fund office in Chicago. The automation includes the development of computer-generated field forms to be used by investigators in the field to improve the accuracy and consistency of type of data being reported, increase potential use of the database, and greatly reduce manual preparation of raw data into the computer. A series of maps produced on this contract identifies the densities of subsidence claims over mined-out areas.

Rock and Soil Mechanics

In addition to the projects described below, major geotechnical support was provided for the SSC and the Earthen Liner projects described elsewhere.

Soil Pressure on Basement Walls (Bradford). A proposal for a project to study lateral pressure against basement walls has been developed, and funding sources are being sought. Data from the Mine Subsidence Insurance Program continue to support the concept that swelling soils cause a significant problem in Illinois. These problem soils result in cracked basements and in some cases, structural failure.

Activities of the Inter-Survey Geotechnical Laboratory (M. Miller, Roeper, Westcott, and Chibani). The Geotechnical Laboratory processed 1,760 particle-size samples of various kinds, 4,500 suspended concentration samples, and 300 miscellaneous samples. These samples came from many projects of the Geological and Water Surveys: the brine project, SSC project, Cashe River project, pesticide projects, wetland project, and numerous lake survey projects.

Geotechnical Information for Four Sites (Bradford). Geotechnical information was prepared to describe conditions at sites for a water tower in Logan County and for a pond in Champaign County. Also, reports for a proposed power plant were prepared for two sites in St. Clair County.

Illinois Affiliate National Cartographic Information Center and Remote Sensing Activities

Satellite Image Map of Illinois (Stohr). The Satellite Image Map was reprinted for the third time in June. More than 15,000 copies have been sold since its release in December 1985. Increased resolution and quality were realized in the third printing through the efforts of Northern Illinois University, the contractor, and ISGS support. Michael Hansen of the Ohio Department of Natural Resources requested and received descriptions of our experience to help Ohio with its proposal for a similar map.

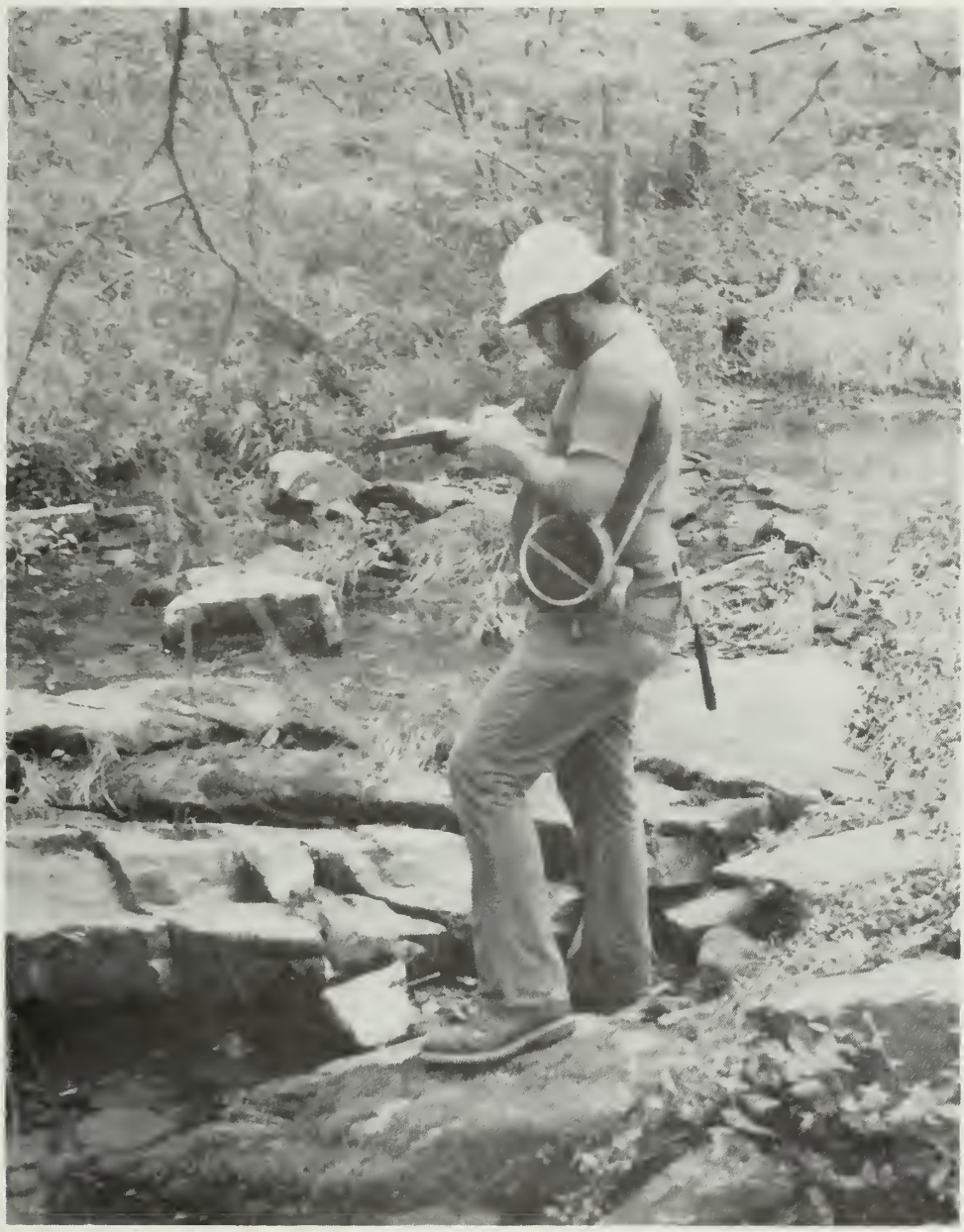
Aerial Photogaphy of the SSC Study Area (Stohr). Black and white aerial photography at a scale of 1:24,000 and at 1:6,000 was obtained for the SSC study area. Photos were assembled and photographed as a photo-index to provide researchers easy identification of needed photography.

Cooperative Topographic Mapping Program (Scoggin and DuMontelle). Four new 7.5-minute topographic maps were completed and published by the U.S. Geological Survey this quarter. Only 20 maps remain to be published to complete coverge of this series for Illinois. Completion of the series is expected early in 1987. The Survey released a new map-style index showing all the names and locations of each 7.5-minute quadrangle map in Illinois. The free index also shows the names of available 15-minute quadrangle maps.

Automated Survey File Information (Scoggin). The Illinois NCIC affiliate office has initiated a project to develop a computerized file of locations and descriptions of monuments used by engineers and surveyors. When completed, this file of "benchmarks" will become a part of the Illinois Natural Resources Information System (INRIS). The information about benchmarks will be available by dialing a toll-free number to access the DENR Prime computer through a modem and personal computer.

Other NCIC Affiliate Activities (Scoggin). The 1:100,000-scale county planimetric mapping program is underway. One Map (Grundy) has been published and 29 other maps are in press. Authorization for mapping of 35 additional counties has been requested. Complete coverage in the 30x60-minute 1:100,000 scale quadrangle series is available for Illinois. The Survey has published a map-style Index to Topography Maps which will be distributed free of charge.

Illinois Mapping Advisory Committee (DuMontelle, Stohr, and Scoggin). The Illinois Mapping Advisory Committee met October 24th in Springfield. The program topic was Digital Spatial Data Bases for State and Local Government Programs: Data Standards and Use of Digital Soils Data. Paul B. DuMontelle was elected to replace Jack A. Simon as Vice-Chairman and Christopher J. Stohr was elected to replace DuMontelle as Secretary of IMAC.



General and Basic Research

Russell Jacobson describes a sandstone on a slope in the Creal Springs Quadrangle during field work for the Cooperative Geologic Mapping Program with the USGS (COGEOMAP) in southern Illinois.

GENERAL AND BASIC RESEARCH

CONTINENTAL SCIENTIFIC DRILLING PROGRAM

Illinois Basin Ultradeep Drillhole (Eidel, Buschbach, Nelson, Kolata, Oltz, Heigold, Bauer, Sargent, Bradbury, J. Frost, Whittaker, Hughes, Cartwright, Goodwin, Shimp, and ISGS staff; D. Anderson, G. Klein, and University of Illinois faculty; W. Hinze and L. Braile, Purdue University; T. Hildenbrand and D. Stanley, U.S. Geological Survey; P. Vail, Rice University; L. McGinness, Argonne National Lab; J. Sexton, Southern Illinois University; E. Lidiak, University of Pittsburgh; R. Keller, University of Texas-El Paso; P. Ervin, Western Illinois University; L. Sloss, Northwestern University; and IBUD investigators). Members of the IBUD consortium prepared three documents during the year: the IBUD Preproposal in the DOSECC format; the IBUD Plan for Science, resulting from the April 1985 workshop; and the IBUD Site Definition preproposal. Eidel presented the Plan for Science at a DOSECC-Scientific Advisory Committee (SAC) meeting at Sky Valley, Georgia and again at DOSECC Workshop at Rapid City, South Dakota. Eidel, Sloss, Hinze, and Vail presented the IBUD Plan for Science and the Site Definition Proposal at a SAC meeting in Denver. Eidel, Hinze, Vail, and McGinness presented the IBUD Site Definition Proposal to the DOE Office of Basic Energy Sciences in Germantown, Maryland.

Eidel appeared before the U.S. Senate Subcommittee on Natural Resources Development and Production to present testimony on the Continental Scientific Drilling and Exploration Act (S.1026).

The IBUD is a comprehensive geoscientific proposal to drill a 30,000-foot hole in southernmost Illinois. Assembly of the proposals has focused scientific attention on the scientific and economic aspects of deep drilling in the Illinois Basin. More than 125 geoscientists have contributed to a synthesis of existing knowledge and aided in the development of the science plan. IBUD, to be located at the junction of the Reel Foot Rift System and the Rough Creek Graben, would provide scientific insight on the nature and origin of the initial rift and of the chronostratigraphic and tectonic events that led to the development of a cratonic basin known as the Illinois Basin. The scientists directed attention to the unexplored 10,000 feet beneath the deepest Illinois Basin drillholes drilled to date.

EOS, Geotimes, and the N.E. Oil Explorer ran articles on the IBUD. A syndicated radio show devoted to the IBUD was broadcast in 50 cities; coast-to-coast newspaper coverage occurred twice, in addition to Illinois TV and newspaper coverage.

The IBUD advanced from one of 33 deephole proposals to one of four. At present the IBUD proposals are being refined. The development of the science plan for IBUD has helped significantly in unraveling the geology of the region.

CRUSTAL STUDIES

COCORP Proposal (Eidel, Heigold, and Leighton; Sexton, Southern Illinois University). A presentation of recently gained geophysical knowledge of the deep Illinois Basin was presented to the Consortium for Continental Reflection Profiling (COCORP) at Cornell University, Ithaca, New York. COCORP is planning an east-west deep seismic profile of the earth's crust across Illinois at approximately 38° 30' north latitude. Such a profile will provide new insight to the configuration of the Illinois Basin and the structure of the crust beneath it.

NEW MAJOR EQUIPMENT

Equipment worth more than $1.25 million has been purchased in FY86 with "Build Illinois" funds. This landmark acquisition of major equipment for research and service heralds a new era in quantitative geology and geochemistry at the ISGS. The following items either have been or are now being installed:

- Gas Chromatograph/Mass Spectrometer (Oil and Gas and Others)*
- Particle-size Analyzer* (Grain-size Analysis)
- Scanning Electron Microscope (Micro-elemental Analysis)*
- X-ray Diffraction Spectrometer (Mineralogy)
- X-ray Fluorescence Spectrometer (Bulk Sample Analysis)
- Isotope Ratio Mass Spectrometer (Isotopic Analysis Gas and Liquids)
- Ultimate Coal Analyzer (C, H, and N)
- Neutron Activation Gamma Ray Detector (Trace Elements)
- Low-Level Liquid Scintillation Spectrometer (^{14}C Dating)
- Polarizing Fluorescent Microscope (Coal Petrography)

*Shared with one or both of the other Surveys.

The ISGS is directly responsible for this equipment. The following equipment, purchased by another of the two Surveys, is shared by the State Geological Survey:

- Ultraviolet Spectrophotometer (NHS)
- Inductively Coupled Spectrometer (WS)
- Elemental Analyzer (NHS)
- Ion Chromatograph (NHS)
- Two Pontoon Boats (NHS)

In FY87 the ISGS is scheduled to receive an additional $142,500 for the following equipment:

- Zodiak Boat
- Porosity and Permeability Analyzer
- Human Resources Computer Package
- Tektronix Color Terminal

"Build Illinois" funds have provided nearly $33,000 for site improvements; an additional $5,300 due in FY87, plus $33,000 for maintenance of equipment. The Survey is grateful to the Board of Natural Resources and

Conservation, to the Department of Energy and Natural Resources, to the Bureau of the Budget, to the General Assembly, and to the Governor for their support in these acquisitions.

GEOLOGIC MAPPING

Bedrock Mapping

Cooperative Geologic Mapping Program with the U.S. Geological Survey in Southern Illinois (COGEOMAP) (Damberger, Danner, Devera, Jacobson, Nelson, Trask, Weibel, and others). The cooperative agreement with the USGS to map fifteen 7.5-minute quadrangles along the southern closure of the Illinois Basin was extended for a third year (FY87). However, cuts in the wake of the Gramm-Rudman bill led to a reduction of USGS support by 25 percent.

The main target of the mapping program is the lower Pennsylvanian coal-bearing sequence. Lower Pennsylvanian stratigraphy and coal resource potential are not nearly as well understood as those of the middle Pennsylvanian, which contains our major coal seams. Prior to the COGEOMAP mapping program, most of the lower Pennsylvanian rock sequence was thought to be of nonmarine origin. The emerging geologic picture shows a much more differentiated geologic section, with vertical and lateral variations covering a broader spectrum of depositional environments than was previously recognized. The discovery of marine influence over a larger proportion of the rock sequence than previously known somewhat diminishes the potential for low- to moderate-sulfur coal resources. Analyses of a few coal cores from the shallow diamond drill holes drilled to date exhibit highly variable sulfur contents (near 1% to more than 5% total sulfur).

Publication of the Shawneetown (IGQ-1), Equality (IGQ-2), and Rudement (IGQ-3) 7.5-Minute Geologic Quadrangles (Lumm, Nelson, and Damberger; Cartographic Group of Northern Illinois University). Shawneetown, Equality, and Rudement Quadrangle maps were published in summer 1986 as the first three geologic quadrangles in the new IGQ map series of the Survey. These maps, authored by Nelson and Lumm, represent a milestone in the Survey's renewed efforts in detailed geologic mapping.

Creal Springs, Stonefort, and Eddyville Quadrangles (Nelson, Jacobson, Trask, Lumm, Devera, Weibel, Damberger, and Danner). Field work on the Creal Springs, Stonefort, and Eddyville quadrangles was completed, and drafts were prepared, reviewed by the members of the mapping team, and then submitted to the USGS for review. Each draft includes a representative cross section, stratigraphic column, and a brief text describing the geology of the quadrangle. The layout is patterned after the recently published maps of the Shawneetown, Equality, and Rudement Quadrangles.

A seven-hole diamond-drill program (total footage, 1,456 ft) aimed at resolving several questions on strata correlation, detecting the suspected presence of faults, and obtaining fresh samples of mapped coal seams was completed during summer 1986.

The drilling and mapping effort shows that the stratigraphic nomenclature for the lower Pennsylvanian requires revision. The cyclothemic models of the past do not fit observed facies distributions. For instance, the Abbott Formation changes from 350 to 400 feet of dominantly deltaic distributary sandstones in the Eddyville Quadrangle (east) to 200 feet of largely marine, fine-grained, thin-bedded strata on the Creal Springs Quadrangle (west). The amount of marine influence in the Lower Pennsylvanian strata is much greater than previously recognized.

The McCormick and New Burnside anticlinal structures are now interpreted as resulting from "thin-skinned" folding and thrusting, under compression from the southeast. A later episode of relaxation and extension resulted in superimposed normal faulting on earlier thrust faults.

Glendale and Waltersburg Quadrangles (Devera, Nelson, Weibel and Baxter). Work on the Glendale and Waltersburg Quadrangles is also progressing. Field work on the Glendale Quadrangle was completed, and compilation will begin as soon as the USGS makes the greenline mylar available for compilations. Some minor additional field work may become necessary to follow up questions raised during the review process. Field work on the Waltersburg Quadrangle has been suspended until Baxter's field notes of the 1960s have been incorporated in a draft based on new mapping primarily of the Pennsylvanian. Any additional field work required will be completed during the current field season. The plan is to move these two quadrangles through the publication cycle together.

Goreville, Lick Creek, and Bloomfield Quadrangles (Nelson, Jacobson, Trask, Weibel, and Danner). Although not included in the COGEOMAP program, the northern part of the Bloomfield Quadrangle has been mapped to trace structures and boundaries beyond the southern limits of the Creal Springs Quadrangle. Field work on the Goreville and Lick Creek Quadrangles was initiated and should be well advanced by the end of the current field season.

Surficial Geology

Mapping of Surficial Geologic Materials (Quaternary) on Creal Springs, Eddyville, Stoneford, and Waltersburg Quadrangles (Dr. Esling and graduate students of Southern Illinois University; Follmer). Through a cooperative agreement with Esling of SIU's Department of Geology, the Quaternary materials of the quadrangles in the COGEOMAP program will be mapped by his graduate students. Follmer, Quaternary geologist, is the principal contact at the Survey and provides advice and guidance on mapping standards. Field and laboratory work on the Creal Springs and Eddyville Quadrangles have been completed, and both maps (and accompanying reports) are in the final stages of compilation.

During the past summer, 26 holes were drilled on the Stonefort and 20 on the Waltersburg Quadrangles. All cores were completely described in the field and sampled at 6-inch or 4-inch intervals. Shear strength was tested in holes, and samples were collected for moisture determination. Particle-size analyses have been completed on 15 cores, and additional analyses, including clay mineralogy, will be completed this spring. As on the Creal Springs and Eddyville Quadrangles, upland deposits were found; the Peoria Loess, Roxana Silt, and Residuum overlie the bedrock. Valley deposits were of variable thickness, more than 42 feet (limit of drill rig) in some places. Rough drafts of the Stonefort and Waltersburg Quadrangles were completed in March. Detailed map unit descriptions are now being prepared.

A subcontract was signed with SIU to map the surficial material of the Glendale and Goreville Quadrangles.

Geophysical Mapping of the Creal Springs, Stonefort, Eddyville, and Waltersburg Quadrangle (Dr. Malinconico and his graduate students at SIU-C; Heigold). The cooperative agreement with SIU includes geophysical mapping (measurement of the gravitational and magnetic fields) of the quadrangles. Preliminary gravity and magnetic maps of the Creal Springs Quadrangle have been completed and are under review. Data collection for the Eddyville Quadrangle is almost complete, and draft maps will be produced in early spring. More than 150 data points were obtained on the Stonefort Quadrangle, and data reduction is underway. Preliminary maps are expected to be available in March/April 1987. Mapping of the Waltersburg Quadrangle should be completed by fall 1987. The agreement for federal FY87 includes work on the Glendale and Goreville Quadrangles.

Geologic Materials in the Upper 20 Feet of the Herod, Karbers Ridge, Rosiclare, and Shetlerville 7.5-Minute Quadrangles (Berg and Killey). The surficial materials in the upper 20 feet were mapped in stack-unit format on the Herod, Karbers Ridge, Rosiclare, and Shetlerville Quadrangles, as part of the pilot CUSMAP project in southern Illinois. Soils on soil survey sheets were classified according to parent materials, yielding a geologic map of the upper 5 feet. Available subsurface geologic information was then combined with the soils data to produce the stack-unit map of the upper 20 feet. Descriptions of 150 exposures were made in the field and used to verify or modify the stack-unit maps.

Geologic Materials in Illinois Mapped to a Depth of 15 Meters (Berg and Kempton). This completed study will be published this year as an ISGS circular that will include four plates. Geologic materials were mapped to a depth of 15 meters throughout the state, and 5,200 map areas containing 815 different combinations of geologic materials were delineated. These geologic data are basic to an understanding of the distribution of surficial deposits and the relation of these deposits to land use. Potential for contamination of aquifers, distribution of shallow groundwater, distribution of sand and gravel and other mineral resources, and engineering properties of materials can all be determined on a regional basis with the statewide stack-unit map.

Landscape-Scale Interactions in the Vermilion River (Follmer and Stanke; E. G. Vachta, University of Illinois). Studies in progress of the Salt Fork and Middle Fork of the Vermilion River between Champaign and Danville show a clear relationship between the surficial materials in the watershed, the gradients or river segments, and biological parameters of river quality. Time-dependent studies are showing variations in amounts of organic and mineral matter in suspension and in the character of bottom sediments; these variations are complexly related to flow conditions. Clay mineral studies indicate reversible shifts in dominance from overland soil erosion to channel scour.

Geomorphic and stratigraphic studies are revealing a complex history in the valleys. Segments with high gradients have been in an erosional mode for about 15,000 years; little evidence for accelerated erosion during historic times has been found. Segments with low gradients have been accumulating sediments in the valley for about the same length of time. Sedimentation

rates appear to have increased somewhat during recent times but are small in comparison to earlier events. Both valleys are experiencing an extension of the eroding segments upstream from their confluence. The project is supported by ENR.

Horizontal Studies in Pedogenic Systems (Follmer; J. P. Tandarich, University of Illinois). Recognition, terminology, and interpretation of weathering profiles and soils continue to be problems. A new effort is being made to evaluate the literature and to develop a functional set of criteria for recognizing a complete soil-weathering profile. Recognition of paleosols (or parts of paleosols) is particularly significant in Quaternary studies because it offers a means of understanding weathered, layered deposits, causes of permeability variation, and the distribution of groundwater and other resources. A handbook on paleosols is in preparation.

GEOPHYSICAL INVESTIGATIONS

Geothermal Investigations

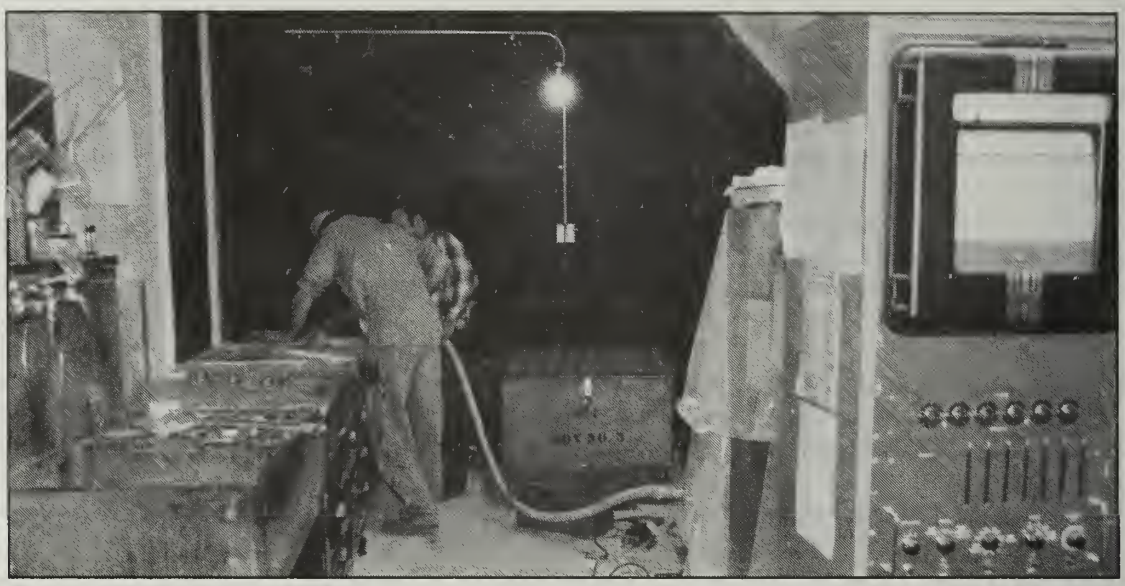
Interpretation of Near-Surface Thermal Surveys (Larson). Pioneering research conducted 20 years ago by members of the Geological Survey staff demonstrated the effectiveness of near-surface thermal surveys in locating groundwater aquifers. Although subsequent work has refined the field methodology and reduced its cost, the use of the method has been hampered by complicated interpretation methods. This project will take advantage of high-speed computers and newly developed numerical models to improve interpretation methods and thereby make the thermal survey a more useful and practical exploration tool.

GEOCHEMICAL INVESTIGATIONS

Isotope Geochemistry

Radiocarbon Age Determination for Samples of Archaeological and Geological Interest (Fisher, Schwartz, and Liu). During the past year, radiocarbon age determinations were made on approximately 135 archeological and geological samples. An equal number of $^{13}C/^{12}C$ determinations were performed during that same period for isotopic fractionation corrections. ISGS researchers requested approximately 42 percent of the sample analyses performed during the period; scientists from other Illinois institutions requested and paid for the remaining 58 percent. Ordinarily, the ISGS radiocarbon laboratory staff can analyze 200 samples per year; however, one of the liquid scintillation counters used broke down permanently in November 1985. Replacement of the counter became possible through the "Build Illinois" program, but delivery was not made until September 1986. Standardization and maximization of performance of the counter have just been completed.

Currently, manuscripts are completed for ISGS date lists XI and XII; these should be published soon. Dates are available for two additional date lists, and these will be written into manuscripts no later than September 1987. Henceforth, the ISGS will be able to publish a date list on an annual basis.



This photograph was taken during site preparation in the clay mineralogy laboratory to make room for the new X-ray diffraction spectrometer, used to study the basic nature of clay. The instrument is now in use.

Leon Follmer (at top) and Dennis McKenna (with bullhorn) were leaders of this field trip, one of several conducted by ISGS staff members during the annual meeting of the American Quaternary Association held in Champaign last spring. The Survey co-hosted the meeting.

CLAY MINERALOGY

Basic Studies of the Structure and X-Ray Diffraction Properties of Clay Minerals (Hughes, Moore, Warren, and Glass). By examining the fundamental nature of clay minerals, ISGS researchers seek to determine the structural characteristics of clay and to account for the X-ray diffraction patterns of poorly understood clays, such as the mixed-layer minerals kaolinite/smectite, illite/smectite, and "smeared" montmorillonite. All three minerals are important indicators of the degree of weathering in Quaternary, Cretaceous, Pennsylvanian, and probably upper Mississippian Strata in Illinois. Illite/smectite and its associated product, diagenetic illite, in oil source rocks and reservoirs may also indicate the thermal maturity of the strata.

Mineral Alteration by Plants, Weathering, and Soil Genesis (Hughes, DeMaris, and Glass). This investigation continues with increasing emphasis on quantifying the rate of alteration of clay minerals by plants, and comparing that rate to alteration produced by percolating water and to the decay of plant material. The unexpected development of mixed-layer kaolinite/smectite (K/S) in association with more easily weathered feldspar grains can apparently result from the thermodynamic instability of very fine crystallites of smectite. K/S formation may also be driven by plant-induced uptake of dissolved SiO_2 at a relatively higher rate than that of K^+, Na^+, and Ca^{++}. Finally, the degree of formation of K/S and "smeared" montmorillonite promises to prove a measure of weathering or alteration intensity--the difference between stable equilibrium conditions for parent minerals and the soil-forming environment and length of time of weathering.

STRATIGRAPHIC INVESTIGATIONS

Quaternary Stratigraphy

The ISGS, with the State Water Survey, State Museum, and University of Illinois Departments of Agronomy, Anthropology, Geography, and Geology, cohosted the American Quaternary Association (AMQUA) Ninth Biennial Meeting in Champaign-Urbana, May 21-June 5, 1986. Leon R. Follmer, David L. Gross, Ardith K. Hansel, and E. Donald McKay served on the local arrangements committee. The theme of the meeting, which was attended by approximately 300 Quaternarists from North America and abroad, was "Environments at Glacier Margins--Past and Present." In addition to 27 invited papers and a panel discussion, 98 poster sessions and abstracts were presented, including those by Brandon B. Curry, Barry W. Fisher, David L. Gross, Ardith K. Hansel, Robert J. Krumm, and Susan O. Miller of the ISGS staff. Four field trips were conducted (and guidebooks prepared) in conjunction with the AMQUA meeting: (1) E. Donald McKay and others, Wisconsinan and Sangamonian Type Sections of Central Illinois; (2) Leon R. Follmer, Dennis P. McKenna, and James E. King, Quaternary Records of Central and Northern Illinois; (3) Ardith K. Hansel, W. Hilton Johnson, and others, Quaternary Records of Northeastern Illinois and Northwestern Indiana; and (4) E. Donald McKay and others, Quaternary Records of Southwestern Illinois and adjacent Missouri. Other ISGS staff who assisted with the AMQUA meeting and/or field trips were Brandon B. Curry, Ed Gefell, David L. Gross, Molly Holden, Myrna M. Killey, Robert J. Krumm, Jack M. Masters, Susan O. Miller, Lisa Smith, and Faith Stanke.

Lake Chronology in the Lake Michigan Basin: 15,000 RCYBP to Present (Hansel). The timing and causes of high lake phases in the Lake Michigan Basin are being reevaluated on the basis of the developing radiocarbon age control on the abandoned Chicago Outlet and the three abandoned beaches at the south end of the basin. Approximately 60 radiocarbon dates from the area have been processed by the ISGS Radiocarbon Lab in the last 5 years. These data provide the basis for a revised lake history and new models relating high lake levels to times when greater amounts of water were coming into the basin from glacier meltwater and precipitation.

Chicago Outlet Drainage History (Hansel). The stratigraphic record preserved in the Chicago Outlet continues to be examined and evaluated with respect to the late Quaternary history of drainage from Lake Michigan to the Illinois Valley. Four new cores were taken in 1984. Comparison of the outlet record with the lake-level record suggests good agreement in the timing of events; the radiocarbon dates from the Chicago Outlet indicate that organics accumulated between those times when the lake was high.

Quaternary Stratigraphy in Northeastern Illinois (Hansel; W. H. Johnson, University of Illinois). In 1985, 5 new cores were taken and 15 new sections described to aid in correlation of lithostratigraphic units in the Wedron Formation and provide available basic geological information on the Greater Chicago Area. Stratigraphic correlations proposed by Hansel and Johnson at the 1986 AMQUA field trip were tested with new field data and borehole data, from which cross sections were constructed. The Lemont Drift-Haeger Till Member Correlation was further documented with these data.

Glacial Sedimentary Environments of the Wedron Formation (Hansel; W. H. Johnson, University of Illinois). Study of the sedimentological characteristics of the Wedron Formation is continuing in an effort to model sedimentary environments and predict probable relationships among glacial materials deposited during the last ice event in Illinois. Several important sections in the Woodstock-West Chicago end moraine complex have been studied in detail, and lithofacies diagrams, clast fabric diagrams, and summaries of analytical data prepared. The results indicate that both the Woodstock and the West Chicago moraines are palimpsest features that contain deposits of more than one glacial event. The abundance of ice-marginal sediments in these moraines (as opposed to subglacial till, which predominates in most Illinois moraines) has important applications in groundwater studies, land-use planning, engineering properties, and locating landfills.

Synthesis of Lake Michigan Lobe Radiocarbon Dates and Chronology of Events (Hansel and Fisher). Radiocarbon dates on organics from beneath, beyond, within, and above late Wisconsinan deposits of the Lake Michigan Lobe in Illinois, Indiana, Wisconsin, and Michigan are being compiled into a single list with additional information (material dated, radiocarbon, lab, location, stratigraphic unit, collector, references, significance) maps, and graphs to synthesize the chronology of events of the last glacial advance and retreat in Illinois.

Reevaluation of Late Holocene Paleo Lake Levels (Hansel, Follmer, and Chrzastowski). Sites at the south end of the Lake Michigan Basin that record lake-level fluctuation in the last 4,000 years are being studied to better understand the timing, magnitude, and causes of late Holocene lake-level fluc-

tuations. The results of this study have important implications in understanding and planning for high lake levels, such as those occurring in the Chicago area during 1986 and 1987.

Applications of Clay Mineral Composition in Quaternary Geology (Glass and Killey). A paper on "Clay Mineral Classification of the Kellerville Till Member, Western Illinois," was presented by Killey at the meeting of the North-Central Section of the Geological Society of America in April 1986. This study concluded that local entrainment, incorporation, and homogenization of older accretion-gley till and bedrock by Kellerville ice produced this till's variable clay mineral compositions. Delineation of areas of Kellerville Till containing large amounts of expandable clay minerals should aid in the location of areas of expansive soils that might be prone to cause foundation failures and other engineering problems during construction and maintenance. These soils may also contibute to slope stability problems.

Reconstruction of the Quaternary History of Illinois from the Mineral Composition of the Materials (Moore, J. Fox, Warren, Hughes, Killey, and Glass). For more than three decades, H. D. Glass has been applying clay mineralogy to Quaternary stratigraphic reconstruction. When he joins the Survey in June, D. M. Moore will assume primary responsibility for this investigation in addition to ongoing regional studies. New correlation matrices are required to compare data from the three X-ray diffractometers at the Survey. Efforts will also continue to find new examples and test the hypothesis that all materials such as till, outwash, lake deposits, and loess from a single ice event will contain a similar and diagnostic composition.

Teays-Mahomet Valley Symposium Volume (Kempton). Subsequent to the GSA Symposium on the Teays-Mahomet System in 1983, a decision was made to publish papers presented at the Symposium as a GSA Special Paper. An ISGS manuscript on the bedrock topography and stratigraphy of the glacial drift fill is now nearing completion.

Paleozoic Stratigraphy

Correlation of Middle Ordovician K-bentonite Beds in Eastern North America by Chemical Fingerprinting (Kolata and J. Frost; W. D. Huff, University of Cincinnati). Two Ordovician K-bentonite beds (altered volcanic ash) have been correlated on the basis of chemical fingerprinting, tracing on geophysical logs, and outcrop studies from southeastern Minnesota through the Illinois Basin to the southern Appalachians, a distance of 1,300 kilometers. These beds can be used as time lines to provide insight into the regional distribution of coeval Ordovician paleoenvironments. Correlation of K-bentonite beds provides a level of accuracy in chronostratigraphy of Middle Ordovician rocks that previously was unattainable. The National Science Foundation is supporting these studies through 1988.

Middle and Late Ordovician Lithostratigraphy and Biostratigraphy of the Upper Mississippi Valley (Kolata; R. Sloan, University of Minnesota). A report on the stratigraphy and paleontology of the Upper Mississippi Valley has been prepared for special Ordovician symposia and field trips to be held at the Geological Society of America (North-Central Section) meeting in St. Paul, Minnesota (April 30-May 3, 1987). The report, to be published in the Report of Investigations series of the Minnesota Geological Survey, includes

range charts of all major macrofossils and conodonts as well as 12 papers by Ordovician specialists working in the Upper Mississippi Valley.

Computerized Stratigraphic Data (J. Treworgy, L. Cooper, and P. Helm). Stratigraphic tops for more than 4,200 drillholes in the Wabash Valley Fault System were added to a computerized stratigraphic database that C. Treworgy is building. For each hole, two to ten stratigraphic tops and, in some cases, information about the hole's position relative to a fault are recorded. At some point in the future, these data, which are compatible with the Basic Well Data File, will be merged with that file.

Sauk Sequence in the Illinois Basin (Sargent). The Sauk Sequence, the oldest sedimentary rocks in Illinois, consists of Cambrian and early Ordovician siliciclastics and carbonates that rest on Precambrian granite and rhyolite. Information on the thickness, distribution, and lithology has important implications for several projects presently underway at the ISGS, including the AAPG Interior Cratonic Sag Basin Volume, the DNAG "History of the Illinois Basin" chapter, the Illinois Basin Ultradeep Drillhole, and the deep aquifer injection of toxic wastes. Because of its extreme depths of burial, more than 20,000 feet in some parts of the basin, few wells penetrate the entire Sauk. An isopach map of the Sauk has been prepared from an analysis of the most up-to-date geophysical and geological data.

Lithostratigraphy and Biostratigraphy of the Everton Dolomite in the Illinois Basin (Sargent, Norby, and Shaw). Efforts to better understand the history of the Illinois Basin from the end of deposition of Canadian strata through the complete transgression of Middle Ordovician seas have required close examination of the Everton Dolomite, the basal formation of the Tippecanoe Sequence in most of the southern part of the basin. The Everton crops out in northern Arkansas and along the eastern flank of the Ozark uplift in Missouri, but occurs only in the subsurface (to depths of more than 7,500 ft) in Illinois, hampering efforts to study its age and lateral and vertical changes in lighology. Only two cores of Everton are available; they have been sampled, and conodonts have been extracted from them. These data have been integrated with data from sample studies of available well cuttings and geophysical log interpretations, and an isopach map of the Everton has been prepared. Thickness ranges from a featheredge at the northern and eastern limits of deposition to more than 500 feet in areas of the basin just south of Illinois in Missouri and Kentucky. Preliminary conodont-age work suggests Everton is mostly Whiterockian, but may be in part uppermost Canadian.

Palynological Correlation of Major Pennsylvanian (Upper Carboniferous) Time Stratigraphic Boundaries in the Illinois Basin with Those in Other Coal Basins of Euramerica (Peppers and Lowry). The final draft of this manuscript was delayed because of publication of several significant studies and analyses of several coal samples recently obtained near major stratigraphic boundaries. Several of these coal samples came from near the Desmoinesian-Missourian Series boundary in Ohio; about 15 sets of core samples from the interval of the Atokan-Desmoinesian boundary in southwestern Missouri were contributed by the Missouri Geological Survey; and several samples from near the Atokan-Desmoinesian boundary were sent by the University of Oklahoma. Palynological data from the Missouri and Oklahoma samples illustrate the overlap of the Atokan and Desmoinesian, since the coals from strata considered Atokan in age contain Desmoinesian spore assemblages as compared with assemblages from the

type area in Iowa and from coals in strata the ISGS assigns to the Desmoinesian. The problem is due to the fact that the two series were originally described from widely separated regions, and the boundaries of the two series are being defined according to fossil zones, even though the type Atoka Formation does not contain fossils. If the top of the Atokan is accepted as originally described, the series boundary in Illinois should be raised from below the coal underlying the Seville Limestone to the top of the Seville Limestone.

At the annual meeting of the Geological Society of America, palynologists with the U.S. Geological Survey and the West Virginia Geological Survey indicated that they have also noted a sudden change in coal-swamp floras at the Desmoinesian-Missourian boundary in the Appalachian Coal Region. Several geologists with the U.S. Geological Survey plan to study the interval in the Appalachian Region and will use geochemical analysis among other methods in an attempt to provide an explanation for the abrupt change.

Palynological Correlation of the Bidwell and Delwood Coal Members (Peppers and Lowry). Palynological data from the Bidwell and Delwood Coals at 23 sample sites are being analyzed. The coal, more widespread than originally thought, has been palynologically identified in nine counties in southeastern Illinois and may extend into Indiana. The Bidwell Coal, which is in the lower part of the Spoon Formation, is correlated with the Delwood Coal, thought to be in the upper part of the Abbott Formation. The Delwood Coal in the type section of the Abbott Formation is actually equivalent to the Litchfield Coal (the Rock Island Coal of northwestern Illinois). Palynological studies show that the overlying limestone called the "Curlew Limestone of southern Illinois" is considerably younger than the type Curlew Limestone of Kentucky and Seville Limestone of Illinois. Botryococcus, a freshwater algae typical of boghead coal, has been found in most of the samples and is abundant in several sites.

Identification and Correlation of Coals in Southern Illinois in Support of COGEOMAP Project (Peppers and Lowry). About 50 coal samples collected by geologists mapping in southern Illinois were palynologically analyzed as an aid in identification and mapping of the coals. One of the major results has been the identification of a coal equivalent to the Tarter Coal of northwestern Illinois. It was also learned that several thin, discontinuous coals of slightly different ages occur in the Caseyville Formation; only the Gentry Coal near the middle of the Caseyville is now formally recognized. The coals are difficult to correlate because of local variations in spore assemblages, so only relative ages can be determined at this time.

Marine Shale in Caseyville Formation (Devera and Peppers; Mason-Morehead State University). Palynology and goniatites were used to determine the age of a shale containing marine fossils in the Caseyville Formation in southern Illinois. Marine incursions were rare during Caseyville deposition. The marine shale discovered during recent mapping has been interpreted as a drowned distributary channel. The presence of several kinds of goniatites and 49 spore taxa indicate a late Morrowan or upper to middle Westphalian A age.

Tri-State Committee on Correlation in the Pennsylvanian System of the Illinois Basin (Jacobson and Trask). This committee was established several years ago to standardize stratigraphic terminology in the Pennsylvanian System

throughout the Illinois Basin coal field, across state boundaries. The geological surveys of Illinois, Indiana, and Kentucky as well as the U.S. Geological Survey are represented on the Committee. Jacobson remained as chairman and Trask as secretary. Currently, the Committee is working on the stratigraphic interval between the Herrin and Danville Coals of the Carbondale Formation and their equivalents.

Nature and Origin of Lower Pennsylvanian Strata of the Illinois Basin (Nelson, Devera, Trask, Howard, and others; DiMichele, Smithsonian Institute). A proposal for funding was submitted to the Petroleum Donors' Fund. Many investigations in this multipronged attack on the nature and origin of the lower Pennsylvanian strata are already in progress. The object is to expand the analysis to a basinwide synthesis.

Conodont Biostratigraphy of the Ancell and Platteville Groups (Shaw and Norby; R. Votaw, Northwestern Indiana University). This biozonation program has been expanded to include an additional four cores and six surface localities distributed from southeastern Minnesota to White County, Illinois, with the intent of delineating a north-south cross section of the Middle Ordovician rocks in the Illinois Basin. The goal is to establish the lateral and time-transgressive relationships of the Ancell and Platteville stratigraphic units. Processing of four of the seven cores to be utilized is nearly complete, and a preliminary report is planned by early 1988. A chitinozoan study of a core from Stephenson County is being completed, and reconnaissance sampling for chitinozoans from the White County core will be done this spring.

Age of the Galena Group in Central Illinois (Shaw; Charles Hart, Ohio State University). Conodont faunas from three cores from De Witt, Douglas, and Champaign Counties are being studied to establish the age of the Galena Group in central Illinois. A preliminary evaluation of the conodont faunas (extremely abundant in this interval) should be completed by the end of the summer.

Stratigraphy of Chicago-Area Silurian Rocks (Mikulic, Norby, and Sargent). The lithostratigraphic and biostratigraphic framework of Silurian dolomites in northeastern Illinois is being reviewed and revised. These rocks are of special importance to construction engineers and producers of crushed rock. Many quarries have been expanded in recent years, exposing new outcrops; these quarry exposures are being studied, and rock samples are being processed for relative age dating.

Biostatigraphic Zonation of the Silurian in Central Illinois (Norby, Sargent, and Mikulic). A 4-inch diameter core of the complete Silurian section at the Lincoln Gas Storage Field in Logan County has been completely processed for extraction of conodont microfossils. The conodonts have been picked and are being identified. Preliminary identifications of the conodonts suggest that the Ordovician-Silurian contact corresponds to the lithologic description, but conodonts recovered from the upper part of the core show that the Silurian-Devonian boundary is somewhat lower than that suggested by the lithology. Conodonts should provide good biostratigraphic correlation of this central Illinois core to many of the type sections in northeastern Illinois and to the outcrop areas in western Illinois.

Silurian Conodont Succession in Western Illinois (Norby, Sargent, and Mikulic). As part of the reorganization of Silurian biostratigraphic research, a study of the Silurian conodont succession begun by Matthew Avcin early in the past decade has been revived. Some outcrops already have been described, but several others will need to be studied and sampled for conodonts. This study should provide precise correlation of biostratigraphic units to a core in Logan County, to recently aquired cores in Brown and Montgomery Counties, and to sections in northeastern Illinois that were reported in a 1985 Geological Society of America field trip guidebook. Understanding of stratigraphic wedge-outs in western Illinois is also an important goal of this study.

Subsurface Geology

The Conodont Biostratigraphy of the Prairie du Chien Group (Shaw and Norby). The preliminary portions of this study were completed this spring, and the project has been expanded to include additional cores from Henry, Pike, and Warren Counties. Current efforts are focusing on the New Richmond Sandstone and Shakopee Dolomite. Evaluation of the collections to date indicate that (1) a probable disconformity exists at the base of New Richmond in northern Illinois; (2) the New Richmond is late medial early Ordovician in age; (3) the Shakopee is late early Ordovician to earliest medial Ordovician in age; and (4) deposition of the Shakopee on the flanks of the basin continued into at least earliest medial Ordovician time, although this portion of the section was removed by erosion in the middle Ordovician. Contacts with private industry are being pursued in the hopes of obtaining additional core material from these intervals. A secondary project in progress is an evaluation of the potential of using well cuttings from the Prairie du Chien for conodont analysis.

History of the Illinois Basin (Collinson and Sargent). Revised extensively several times, this project was finalized in March. A major contribution of this summary article is a revised Precambrian surface map that includes the newly discovered 20,000-foot Grayville Graben and new data on the Rough Creek and Mississippi Valley Grabens.

STRUCTURAL GEOLOGY

Shatter Cones and Other Evidence for Meteoroid Impact at Glasford and Des Plaines (Sargent, McHone, and Nelson). Shatter cones have been discovered in rock cores from the Glasford and Des Plaines Disturbances. Percussion fractures, microbreccia veinlets, planar elements, and strained-quartz grains have also been found at both localities. Shatter cones are diagnostic of an ultra-high velocity impact; the other features add to the weight of evidence suggesting meteoroid impact. Previously, these structures had been listed as possible impact structures on world lists of such phenomena; they will now be raised to the level of probable impact structures.

Structural Features of Illinois - An Encyclopedia (Nelson). The text of this catalogue of all named structural features in Illinois is almost completed, and figures and maps are in preparation. This publication is intended as a companion to Bulletin 95, the handbook of stratigraphic terminology in Illinois. All named structures in the state will be presented alphabetically, with descriptions, location maps, appropriate illustrations, and references.

History of the Kankakee Arch (Atherton, Collinson, and Buschbach). This project, begun last year, will be completed by fall.

PALEONTOLOGY/PALYNOLOGY

Eleven scientists contribute to the programs:

- Russell A. Peppers (Coal Section) supervises the Palynological Laboratory.
- Rodney D. Norby (Stratigraphy and Surficial Geology Section) is curator of the Geological Survey Paleontologic Collection and also supervises the Conodont Laboratory and Acid Digestion Laboratory.
- James W. Baxter (Head, Industrial Minerals Section) supervises the Foraminiferal Research Laboratory.
- Dennis R. Kolata (Basin Analysis Task Force) specializes in the study of Ordovician echinoderms.
- Philip J. DeMaris (Coal Section) studies megafloras in the Pennsylvanian coal-forming swamps.
- Joseph A. Devera (Coal Section) studies Pennsylvanian goniatite cephalopods and trace fossils and Middle Devonian chitinozoa.
- Russell J. Jacobson (Coal Section) studies Mississippian and Pennsylvanian invertebrates.
- Donald G. Mikulic (Industrial Minerals Section) studies early Paleozoic arthropods.
- Charles Collinson (Head, Stratigraphy and Surficial Geology Section) specializes in Devonian-Mississippian invertebrates and conodonts.
- Thomas H. Shaw (Stratigraphy and Surficial Geology Section) studies Ordovician conodonts.

The Paleontological Repository

The Paleontological Repository receives, curates, and preserves as a basic data set the fossils and locality descriptions collected and studied by the staff and other scholars. It contains 81 formally catalogued and curated Survey collections, dozens of uncatalogued field collections, and several reference collections of international significance. A Paleontological Research Committee has been organized to advise research planning.

Repository Reorganization (Norby). The Curator, with the assistance of several other Survey paleontologists (Devera, Jacobson, Mikulic, Shaw, and Weibel), has sorted through approximately 500 of the more than 1,000 drawers of fossils in the stratigraphic collections and culled out fossils with poor or nonexisting locality or stratigraphic information. This process not only improves the utility of the collections, but creates space for new materials.

Cambrian Fossil Collection from Wisconsin (Norby). A collection of more than 1,000 fossil specimens from the Cambrian of Wisconsin was sorted with the assistance of Don Mikulic. Most of these fossils were collected by Gilbert Raasch and belong to the Survey, but others had been borrowed from the University of Wisconsin-Madison and the Milwaukee Public Museum. Several hundred specimens have been returned to the University of Wisconsin-Madison.

Paleontological/Palynological Studies

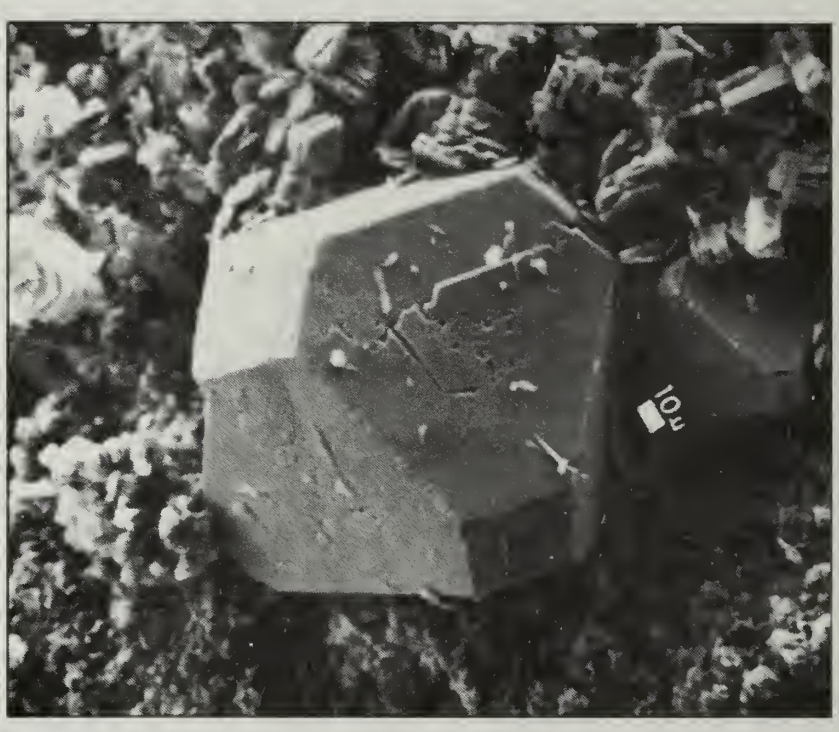
Paleontologic Research Committee (Devera, Jacobson, Weibel, Peppers, Baxter, Collinson, Kolata, Mikulic, Norby, and Shaw). During the early part of the report period, this Committee formed as an ad hoc group to consider the disposition of portions of Survey collections. Other items of paleontologic research interest were also examined by the Committee, and in the fall of 1986 the Committee became an official working committee of the Survey. Work is continuing on the Survey's large collections, and the feasibility of preparing a fossil handbook is being discussed. Plans are also being made to computerize the catalog for the ISGS fossil collections.

Trace Fossils of the Lower Pennsylvanian (Devera). The primary goal of this work, an outgrowth of the COGEOMAP Program, is to define marine zones within the various lithologies being mapped on the basis of ichnofaunal assemblages. These trace fossil assemblages have already proven to be good indicators for both marine and nonmarine sandstones in the Eddyville, Stonefort, Waltersburg, Glendale, and Creal Springs Quadrangles. A reference collection of ichnofossils consisting of 98 labeled specimens from the mapped quadrangles has been compiled.

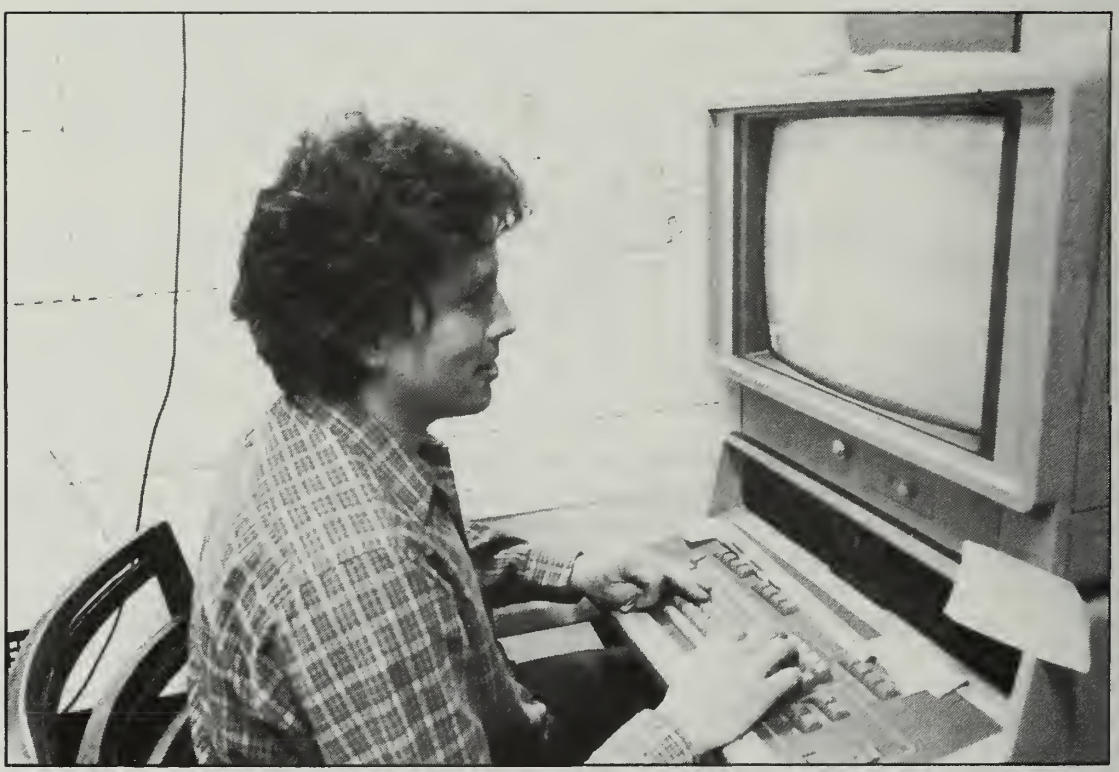
The trace fossil data, integrated with mapping information, fossil plants, and drillhole data, will facilitate efforts to delineate fresh-water paleoenvironments that typically contain low-sulfur coals. The report to accompany the Creal Springs, Stonefort, and Eddyville Quadrangles will contain a significant section on trace fossils.

Goniatites in the Lower Pennsylvanian of Southern Illinois (Devera). The geographic range of certain Pennsylvanian goniatite cephalopods has been extended from Texas to the Illinois Basin. The documentation of a previously unknown large-scale marine transgression in a sequence of lower Pennsylvanian sandstones previously thought to be of fluvial origin has significantly changed the ancient depositional picture of the Illinois Basin.

Mechanized Preconcentration of Conodonts from Acid Residues (Khan, Norby, and Baxter). Handpicking of conodonts from the acid residue of the host rock is tiresome and time-consuming. To accelerate this process and to mechanize the process of concentration of conodonts, various mineral processing methods were tried. The test results showed that flotation of the material without preparation of the feed, which would have resulted in the comminution of conodonts, is not very promising. During the course of the investigations, it was observed that the conodonts preferably attach to waxed surfaces. Although some preconcentration of conodonts was possible using wax-coated surfaces, processes utilizing this property of conodonts did not result in a total and selective recovery of conodonts.



This photomicrograph, taken with the new scanning electron microscope (SEM) shows two large pyrite crystals (magnified more than 600 times) against a background of kaolinite-like crystals (left) and siderite (right). The SEM, acquired with "Build Illinois" funding, is an invaluable research tool.



Rob Krumm edits a map of surface mine boundaries at a GIS work station. The GIS (Geographic Information System) is a computerized database that enables users to store, manipulate, and retrieve graphic and tabular data. The GIS is used for projects in several sections of the Survey.

Miscellaneous (Peppers). As the only palynologist in the Middle Pennsylvanian Working Group of the International Subcommission of the Carboniferous, Peppers continues to provide palynologic input toward the Group's mission to recommend a stratotype for the middle Pennsylvanian. The Group is also to provide criteria for defining series boundaries.

Micropaleontology

Taxonomic Study of the Conodont Genus Lochriea (Norby; von Bitter, Royal Ontario Museum). A study to redefine the Mississippian conodont genus, Lochriea, and about five species has been started to make the genus more useful as a biostratigraphic indicator. This genus and all of its species have an international role as biostratigraphic indicators for the upper Visean and Namurian rocks.

COMPUTER RESEARCH AND SERVICES

Illinois Lands Unsuitable for Mining Program

Lands Unsuitable for Mining Program (McKay, Krumm, Pool, and E. Smith). This program is funded by the U.S. Office of Surface Mining (Department of the Interior) through the Illinois Department of Mines and minerals (IDMM). Its major emphasis during the past 3 years has been to establish an extensive natural resources database, which resides in the Lands Unsuitable Geographic Information System (GIS). The program's scope has expanded to include the development of a very detailed database for coal mining permit applications. Hardware has been purchased and a hands-on training program will be conducted to teach IDMM personnel to access and use the database.

Mine Permit Review Project (Krumm, Pool, E. Smith, and McKay). A database is being developed to assist the IDMM with its Mine Permit Review Program. The GIS is being used to generate maps of features--coal resources, geology, and well locations, for example--that are part of the GIS database and relevant to individual mine permits. New data from each permit are being automated and added to a detailed mine site database. A pilot study for two mine sites demonstrated that this approach was useful to IDMM. Maps have been prepared for three additional permit areas: the Burning Star No. 5 Mine in Jackson County, the John Ross Preparation Plant in Franklin County, and a mine refuse disposal site in White County. The project is now automating mine permit information for Perry County, where 29 permits are currently filed.

Well Information Database (E. Smith, Pool, Krumm, and McKay). The Mine Permit Project has developed a Well Information Database. Mine permits include valuable information: detailed descriptions of borings for coal exploration and overburden analysis, and data on physical and chemical characteristics of rocks and soils. These data have been added to the GIS databases. In addition, well descriptions from the Geological Records files for permit areas have been interpreted and stratigraphic information from those wells included in the Well Information Database.

Other Computer Research and Services Activities

Geographic Information System Staff Training (Krumm and Wilson). During this past year, four one-week training sessions in the use of the GIS have been conducted for 16 staff members by Computer Research and Services Section (CRSS) staff. Hands-on experience included the automation and plotting of maps with RC/INFO software. Staff members were taught to produce base maps (with ILLIMAP), plot well points, automate maps, input tabular overlay, analyze and attribute maps, and produce final maps. Five additional staff members were trained to automate maps with the digitizing equipment.

Geographic Information System Applications (Krumm, Pool, and E. Smith). As the number of projects using the GIS continues to increase, CRSS staff provide advice and counsel to a growing community of GIS users. Custom maps for publications and slides are produced, cartographic data automated, GIS data sets manipulated, and base maps and well-point location maps produced. Two maps of the State showing soil thermal resistivity and soil thermal diffusivity were prepared for the Renewable Resources Project. (These maps were derived from the soil parent materials map.) A map showing mine subsidence events in Illinois was prepared and appeared in a national publication on coal mine subsidence problems. Maps showing quarry and sand and gravel pit locations in northeastern Illinois were compiled for the SSC Site Screening Project. Several maps prepared for the SSC Atlas were produced by CRSS staff using GIS information.

Geographic Information System Workshops, Seminars, and Presentations (McKay and Krumm). Seminars, presentations and workshops describing GIS methods and applications were given this year to more than 100 individuals from universities, geological surveys, and other organizations. Delegations from the U.S. Geological Survey, U.S. Army Corps of Engineers, Illinois Department of Mines and Minerals, U.S. Fish and Wildlife Service, and others reviewed the uses made of GIS at the Survey. The versatility, practicality, and wide range of applications of the Survey's GIS work continues to attract groups from many parts of the nation.

Earthquake Hazard Mapping with the Geographic Information System (McKay, Krumm, Killey, and DuMontelle). At the request of the Illinois Emergency and Disaster Agency (IESDA), a computer model of Richland County was developed to produce maps showing the relative seismic ground movement based on the assumed seismic response properties of glacial deposits. The model was combined with maps of lifeline services to identify those most vulnerable to earthquake damage. Because the seismic response of glacial deposits is not well known, the modeling effort is preliminary and highlights the need for detailed research to relate engineering properties to particle motion in glacial deposits.

Major Upgrade of GIS Software - Interative Arcplot (Pool). In order to speed the production of maps from the GIS, an interactive procedure was written to replace tedious batch environment processing. The current procedure requires the user to edit lengthy programs to make changes, which can be viewed only after the program is rerun. The new interactive program allows users to change a map or move a feature with a single command and to see the

results immediately on a color terminal. In addition to being faster and more user friendly, the program allows easier manipulation of maps. It is the basis for prototype programs being developed to allow novice users to produce maps of wells and public land survey data without prior training.

Processing of Data for UI Department of Plant Biology (Gaines). In continuing cooperation with the Department of Plant Biology of the University of Illinois, the Computer Research Section of the Survey is providing data entry and analysis services. Plant macrofossil assemblages found in coal balls from all major coal seams in Illinois are entered into the very large data files that are used for paleoenvironmental reconstructions.

Correction of the ILLIMAP Database (McKay and Gaines). ILLIMAP, one of the Survey's largest computer files, needs substantial correction and update. Substantial time and computer resources are being used to correct the Paducah 1° x 2° quadrangle. The file contains the public land survey system for the state and is used with the GIS to produce base maps and to locate wells from legal descriptions. New 7.5-minute quadrangle maps received from the USGS will be digitized as the update process continues.

Computer Automation of Map Information for CUSMAP (Pool, E. Smith, Krumm, and McKay). A 1:100,000-scale geologic map of the Hick's Dome Pilot Study area was prepared by Nelson and compiled and digitized by CRSS. Digitizing required the reformatting of standard geologic map information into separate map overlays containing different types of features, such as faults and formation contacts. A map of all wells in the pilot area was completed, and a database of well attributes was begun. A stack-unit map prepared by Berg and Killey was also digitized. These maps will be used in the evaluation of the GIS as a tool in mineral assessment studies for the Paducah Quadrangle.

Translation of a USGS Computer Program for Contouring (T. Johnson). As part of the CUSMAP program the USGS has given the Survey a computer program for gridding and contouring geologic data. The program, written on a Vax computer, has been translated to run on the ENR Prime 9955 computer. The revised version will be made available to all Prime users. This program adds significantly to the computer mapping capabilities of the Survey.

Computerized Data on Highway Pavement Performance (Krumm). The ISGS and the University of Illinois Department of Civil Engineering have cooperated to produce computer-based maps of interstate highway pavement performance using the GIS. The data include over 400 attributes of pavement performance, traffic load, and other factors affecting performance for each mile section of interstate.

Master Mailing List Project (Denhart). Mailing lists are vital to the dissemination of geological information. The many lists maintained by hand or on a variety of computer hardware have been consolidated into a Master Mailing List System on the Prime computer. This system is designed not only for mailing list production, but also for construction of an order/interest history of customers to assist in future marketing.

Computer Needs Analysis and Computer Systems Evaluation (McKay and Wilson). The Computer Committee conducted a detailed survey of the ISGS computing needs and concluded that a substantial expansion of computing facilities and capabilities should be made over the next 5 years. The Committee is evaluating several computer hardware options (Prime, DEC Vax, Harris, and Britton-Lee computers) and has investigated software available for high-speed management of large databases and for more sophisticated mapping. It also has contacted the National Center for Supercomputing Applications at the University of Illinois to explore the application of supercomputing technology to earth science problems in general and to siting the SSC.

Formation of Illinois Basin Section of Computer-Oriented Geological Society (COGS) (Jacobson). During the report period Jacobson led the formation of a local section for the COGS. With the help of several members of the Illinois and Kentucky Surveys, plus some industry geologists, Jacobson achieved formal recognition for the COGS from the national society. More than 45 geologists attended when the Section held its first annual meeting, and Jacobson was elected the Section's first president.

Administrative and Scientific Support Services

The hydraulic levelling jack Dave Cooley constructed for the tongue of this mobile drill makes it possible to adjust the drill rig for use on rough terrain.

ADMINISTRATIVE AND SCIENTIFIC SUPPORT SERVICES

Support services include managing the ISGS Library and receiving and distributing incoming mail, commodities, and equipment; processing and shipping outgoing orders for publications, maps, and other materials; maintaining the telephone switchboard and information office; conducting public field trips, dealing with a variety of inquiries, distributing educational materials and overseeing press relations; fabricating, maintaining, and repairing scientific, office, automotive, and other equipment and instruments; supervising the word processing system; providing editorial, graphics arts, typography, and publications services; and planning and supervising new construction and building renovations.

PUBLIC RELATIONS UNIT

A separate public affairs unit was established in January 1987 to publicize and promote the research, service activities, programs, and events of the Geological Survey. Utilizing such avenues as articles for newspapers and journals, speeches or lectures, press releases, reports, brochures, and public displays, information will be channeled to the news media, industry, the public, and special interest groups.

The Geological Survey's news will also be disseminated through special events, such as open houses, field trips, and press conferences arranged to highlight the work and/or discoveries of the scientists and their support teams. Because a closer liaison is sought between ISGS and such groups as the Society for the Illinois Scientific Surveys, news sources, news media and target groups, this unit will provide a continuous flow of in-depth information to each of them, thereby keeping these special groups apprised of the Survey's progress and impact on Illinois' economic development/protection of its natural resources.

During the past fiscal year, the Survey held an Illinois Superdeep Drill Hole Workshop, which generated news coverage by television, radio and the press. Press releases also were generated for the Superconducting Super Collider, geological science field trips, the Satellite Image Maps for the state and Northeastern Illinois, and the new geological quadrangle maps of portions of southern Illinois.

PUBLICATIONS, GRAPHICS, AND PHOTOGRAPHY UNIT

Scientific poster presentations became the Unit's leading product in 1986-87, although reports, ISGS series publications, and papers remained the core of our production. Two new products were introduced: Geonews, the ISGS newsletter, and the Environmental Screening Atlas, a major full-color compilation of maps for the SSC program. Other major projects included three 56- by 35-inch stack-unit maps of Illinois geology, speech/slide shows, proposals,

and guidebooks. The staff also prepared displays, brochures, fliers, forms, and ads; edited abstracts, papers, and speeches; provided photodocumentation of projects; assisted scientists with organizing and illustrating data at pre-technical-review stages; and assessed projects for time, complexity, resources, staff, and costs.

A significant shift in products and service became apparent during the last 12 months. The Publications Unit

- doubled output of scientific poster presentations. The leap in demand (up 100% from 1985-86) may be partly attributed to fast turnaround, attractive design, full-color graphics, and customized editing/writing services.

- introduced the first three issues of a newsletter developed to increase staff awareness of the wide variety of work in progress at the Survey and inform interested laymen (including legislators, DENR staff, board members, and selected officials of government agencies, industry, and the local community) about the Survey's contributions to the state's economic and environmental welfare. Special in-depth editions, such as the 12-page Winter-Spring 1987 issue highlighting ISGS research on groundwater protection, will alternate with short 4- to 6-page issues covering a broad range of programs and projects.

- produced the full-color Environmental Screening Atlas for the SSC program (1 1/2 years from concept to distribution).

- advanced from manual composition of type to digital typography with the purchase and installation of an Allied Linotype typesetter.

- expanded project assessment services from proposal to mid-production stages to determine project size and complexity; estimate staffing, materials, and other resource needs; and calculate schedules and costs. Scientific staff receive an accurate perspective of all factors and costs involved in publication.

Changing needs and unexpected demands have challenged the core staff of 2 editors, 3 graphics artists, production assistant, photographer, typographer, and coordinator/editor. Expanding and contracting business has required flexible staffing--a permanent core plus reliable free-lance talent.

Despite the loss of an editor for three months (due to a personnel change), production for 1986-87 was high.

Completed Publication Projects May 1986 - March 1987	1983-84	1984-85	1985-86	1986-87
Atlas - Environmental Screening SSC	--	--	--	1
Scientific Poster Presentations	8	7	15	30
Geonews	--	--	--	3
Circulars	1	4	2	4
Illinois Mineral series	2	2	2	2
Environmental Geology series	2	6	3	6
Illinois Petroleum series	1	1	1	0
Contract/Grant Reports	5	3	5	3
Field Trip Guides	3	2	4	4
Major guidebooks	0	3	0	3
Cooperative Groundwater Reports	1	0	1	0
IL Scientific Survey Joint Reports	--	1	0	0
Reprints	12	11	14	16
Abstracts	29	35	11	6
Papers, articles, and published speeches	13	37	25	24
Large plates	15	16	3	3
Brochures, booklets, fliers	1	3	4	13
Special reports, proposals, other projects	--	16	36	15
TOTALS	92	146	126	133

ISGS publications for the 11-month period of May 1986 through March 1987 include the following:

Scientific Poster Presentations: J. P. Kempton, R. C. Berg, S. O. Miller, J. Treworgy, R. E. Hughes, H. E. Glass, R. Warren, B. W. Fisher, D. E. Laymon, R. J. Krumm, K. Albrecht, B. L. Herzog, J. J. Eidel, R. R. Ruch, H. H. Damberger, L. R. Follmer, R. H. Shiley, D. L. Reinertsen, L. Smith, M. Rostam-Abadi, J. DeBarr, D. Moran, J. B. Risatti, L. R. Camp, H. P. Ehrlinger, R. B. Read, M. L. Sargent, D. F. Oltz, and C. Collinson.

Circular Series: comprehensive reports and reference works representing completion of a major phase of geologic research, a critical development in stratigraphy, or other substantive and enduring compilation of data.

C 537 K-Bentonites of the Ordovician Decorah Subgroup, Upper Mississippi Valley: Correlation by Chemical Fingerprinting. D. R. Kolata and J. K. Frost. 20 p., 19 figs., 6 tables. (completed)

C 538 Structural Geology of Southeastern Illinois and Vicinity. W. J. Nelson and D. K. Lumm. 72 p., 29 figs., 1 table. (completed)

C 539 Stratigraphic Correlations of the Seelyville, Dekoven, and Davis Coals in Illinois, Indiana, and Western Kentucky, R. J. Jacobson. 28 p., 12 figs., 7 tables, 2 plates. (completed)

C 540 The Hornsby District of Low-Sulfur Herrin Coal in Central Illinois (Christian, Macoupin, Montgomery, and Sangamon Counties). 65 p., 28 figs., 1 plate. (completed)

Illinois Mineral Series: reports of significant advances in basic and applied research in the area of mineral resources, or compilations of mineral economic data.

IMN 94 Coal Recovery from Mine Wastes of the Historic Longwall Mining District of North-Central Illinois. L. A. Khan, D. J. Berggren, and L. R. Camp. 19 p., 17 figs., 8 tables. (completed)

IMN 95 Illinois Mineral Industry in 1984 and Review of Preliminary Mineral Production Data for 1985. I. E. Samson and S. B. Bhagwat. 44 p., 11 figs., 25 tables. (completed)

Environmental Geology Series: reports of significant advances or pivotal discoveries in basic and applied environmental geological research.

EGN 114 Design Principles for a Coal Desulfurization Process with Iron Sulfides as In Situ Catalysts. R. H. Shiley, R. E. Hughes, K. L. Konopka, C. C. Hinckley, G. V. Smith, T. Nishizawa, N. Yoshida, and M. Saporoschenko. 9 p., 5 figs., 6 tables. (completed)

EGN 115 Inorganic Composition and Sedimentation Rates of Backwater Lakes Associated with the Illinois River. R. A. Cahill and J. D. Steele. 61 p., 12 figs., 16 tables, 4 apps. (completed)

EGN 116 Assistance to Six Small Water-Short Communities in Illinois: Electrical Resistivity Surveys. V. L. Poole. 48 p., 25 figs. (completed)

EGN 117 Geological-Geotechnical Studies for Siting the Superconducting Super Collider in Illinois: Results of the Fall 1984 Test Drilling Program. J. P. Kempton, R. A. Bauer, B. B. Curry, W. G. Dixon, Jr., A. M. Graese, P. C. Reed, M. L. Sargent, and R. C. Vaiden. 102 p., 54 figs., 25 tables. (completed)

EGN 118 Characteristics and Potential Uses of Waste from the Historic Longwall Mining District in North-Central Illinois. S. C. Bradford, D. J. Berggren, and P. B. DuMontelle. 50 p., 22 figs., 4 apps. (completed)

EGN 119 Hydrogeologic Evaluation of the Effects of Surface Application of Sewage Sludge to Agricultural Land Near Rockton, Illinois. R. C. Berg, W. J. Morse, and T. M. Johnson. 42 p., 14 figs., 5 tables. (completed)

Contract/Grant Reports: timely reports of research generated in response to specific geologic and environmental issues. Note: many contract reports are produced by Survey scientists, yet are not published in the ISGS series.

1986-1 Information System on Illinois Coal II: Characterization of Samples in the Illinois Basin Coal Sample Program. R. D. Harvey, A. Kar, and J. D. Steele. 33 p., 3 figs., 8 tables, 1 app. (completed)

1986 A Study of Trench Covers to Minimize Infiltration at Waste Disposal Sites. K. Cartwright, T. H. Larson, B. L. Herzog, T. M. Johnson, K. A. Albrecht, D. L. Moffett, D. A. Keefer, and C. J. Stohr. 122 p., 89 figs., 1 app. (completed)

1987-1 Geologic Characteristics of Illinois Gravel Deposits Affecting IDOT Freeze-Thaw Test Results. John M. Masters and R. Douglas Evans in cooperation with Illinois Department of Transportation. 98 p., 32 figs., 25 tables, 1 app. (completed)

Educational Extension Materials:

1986-A Carbondale: Geological Science Field Trip. April 1986. D. L. Reinertsen.

1986-B Ottawa: Geological Science Field Trip. May 1986. D. L. Reinertsen

1986-C Batavia: Geological Science Field Trip. October 1986. D. L. Reinertsen.

1986-D Charleston: Geological Science Field Trip. November 1986. D. L. Reinertsen, J. M. Masters, V. Gutowski, and E. Mears.

Geological Science Field Trip Brochure: 1986-87

Reprints of Papers Published in Journals:

1986J Late Wisconsinan and Holocene History of the Lake Michigan Basin. A. K. Hansel, D. M. Mickelson, A. F. Schneider, and C. E. Larsen.

1986K Mineral Matter in Illinois and Other U.S. Coals. R. D. Harvey and R. R. Ruch.

1986L Urban Encroachment on Dolomite Resources of the Chicago Area, Illinois. D. G. Mikulic and J. H. Goodwin.

1986M Recovery of Fine Grained Quartz Sand and Kaolin from Abandoned Sand Washing Tailings Ponds--A Feasibility Study. L. A. Khan, S. B. Bhagwat, J. W. Baxter, and D. J. Berggren.

1986N Factors Affecting Comminution of Clay Particles in a Vibrating Bead Grinder. L. A. Khan, R. E. Hughes, D. J. Berggren, and J. W. Baxter.

1986O Evaluating the Feasibility of Secondary Recovery of Coal from Mine Wastes. L. A. Khan and J. W. Baxter.

1986P Coal Research: A Continuing Need. N. F. Shimp

1986Q Hydraulic Conductivity at a Hazardous Waste Disposal Site: Comparison of Laboratory and Field-Determined Values. B. L. Herzog and W. J. Morse.

1986R Surficial Geology and Soils of the Rhoads Archeological Site near Lincoln, Illinois. L. R. Follmer.

1986S Economic Feasibility of Recovering Fines from Waste Streams of Mineral Processing Plants. L. A. Khan, S. B. Bhagwat, and J. W. Baxter.

1986T Magnetic Anomaly of a Single Steel Drum - Field Profiles and Theoretical Models. R. H. Gilkeson and D. E. Laymon.

1986U U.S. Fluorspar in a Cost/Price Crunch. S. B. Bhagwat.

1986V Domestic Utilization of High Sulfur Coals: Trends and Prospects. S. B. Bhagwat.

1986W Using a Relational Data-Base Management System to Help Determine Causes of Damage to Structures in Illinois. S. C. Bradford, P. B. DuMontelle, R. A. Bauer, and R. D. Evans.

1987A Provenance of Late Wisconsinan (Woodfordian) Till and Origin of the Decatur Sublobe, East-Central Illinois. W. H. Johnson, D. W. Moore, and E. D. McKay.

1987B Economics of Secondary Recovery of Coal. L. A. Khan, S. B. Bhagwat, and J. W. Baxter.

Special Publications

Siting the Superconducting Super Collider in Northeastern Illinois: Environmental Screening Atlas. J. K. Hines with contributions by staff from the Illinois State Geological, Natural History, and Water Surveys and the State Museum. 96 p., 42 maps. (full-color publication; completed)

ISGS Geonews: Spring and Fall, 1986, and Special Issue on Groundwater Protection, Winter-Spring 1987. (3 issues: researched, written, designed, and illustrated by Publications staff)

3 Geologic Maps: Stack-Unit Map of Northern Illinois, Stack-Unit Map of Central Northern Illinois, and Stack-Unit Map of Central Southern Illinois. R. C. Berg and J. P. Kempton.

Brochures, booklets, and fliers for the Satellite Image Maps program, library, and all ISGS publications and maps since summer 1986. (new service)

American Quaternary Association Guidebooks

Quaternary Records of Central and Northern Illinois. L. R. Follmer, D. P. McKenna, and J. E. King. 84 p.

Wisconsinan and Sangamonian Type Sections of Central Illinois. E. D. McKay and B. W. Styles. 48 p.

Quaternary Records of Northeastern Illinois and Northwestern Indiana. A. Hansel, W. H. Johnson, K. L. Cole, T. Thompson, P. Clark, R. Gergen, and G. Fraser. 106 p.

Graphics, Typography, and Photography	1985-86	1986-87
Illustrations (no. of items)		
Miscellaneous maps, graphs, charts, diagrams, and cross sections	913	1,030
Graphics for ISGS publications only	258	458
Plates (larger than 8 1/2 x 11 in.)	3	6
Covers for Publications	31	22
Typesetting (no. of pages)		
Slide copy	127	448
Text, tables, forms, charts, ads, etc.	1,690	1,709
Photography		
Photos taken for staff	1,283	1,134
2 x 2 in. slides: color/blue foil	3,724	4,247
duplicates	1,991	2,514
PMT prints developed for staff	4,622	5,721
Prints made	3,987	4,102
Portraits taken	27	11
Color prints made	52	61
Mylars made	180	215
Black/white film developed for staff (rolls)	82	70
Color film developed for staff (rolls)	161	192
Screened PMTs for staff	437	522

Reproduction by Diazo Process

Division by Groups and Sections	1985-86	1986-87
Information and Technical Services:		
Oil and Gas Development	3,206	1,594
Illinois Coal Mines	815	293
Other	217	291
Northern Illinois Planning Commission (Geology for Planning)		232
TOTAL	4,238	2,410

	1985-86		1986-87	
	Mylar	Paper	Mylar	Paper
Mineral Resources	11	205	6	72
General and Environmental Geology	36	208	14	141
Chemical and Mineral Engineering	--	--	--	--
Administrative Services	2	150	0	31
TOTAL	49	563	20	244

EDUCATIONAL EXTENSION

The Educational Extension Unit provides information and materials on the state's geology, mineral resources and landscape to elementary, high school and college teachers, students and interested laymen. The staff also presents slide-illustrated talks concerning research and service activities at the Geological Survey to teacher workshops, high school science classes, clubs and citizen groups throughout the state.

Geological Science Field Trips (Reinertsen et al.). Although designed to furnish teachers with background materials for classroom use, the four Geological Science Field Trips held each year have become popular events for the general public as well. Field trips and their attendance this year were: Carbondale, 19 April 1986, 100; Ottawa, 17 May 1986, 148; Batavia and Fermilab, 4 October 1986, 42 (cold, rainy day); and Charleston, 1 November 1986, 131.

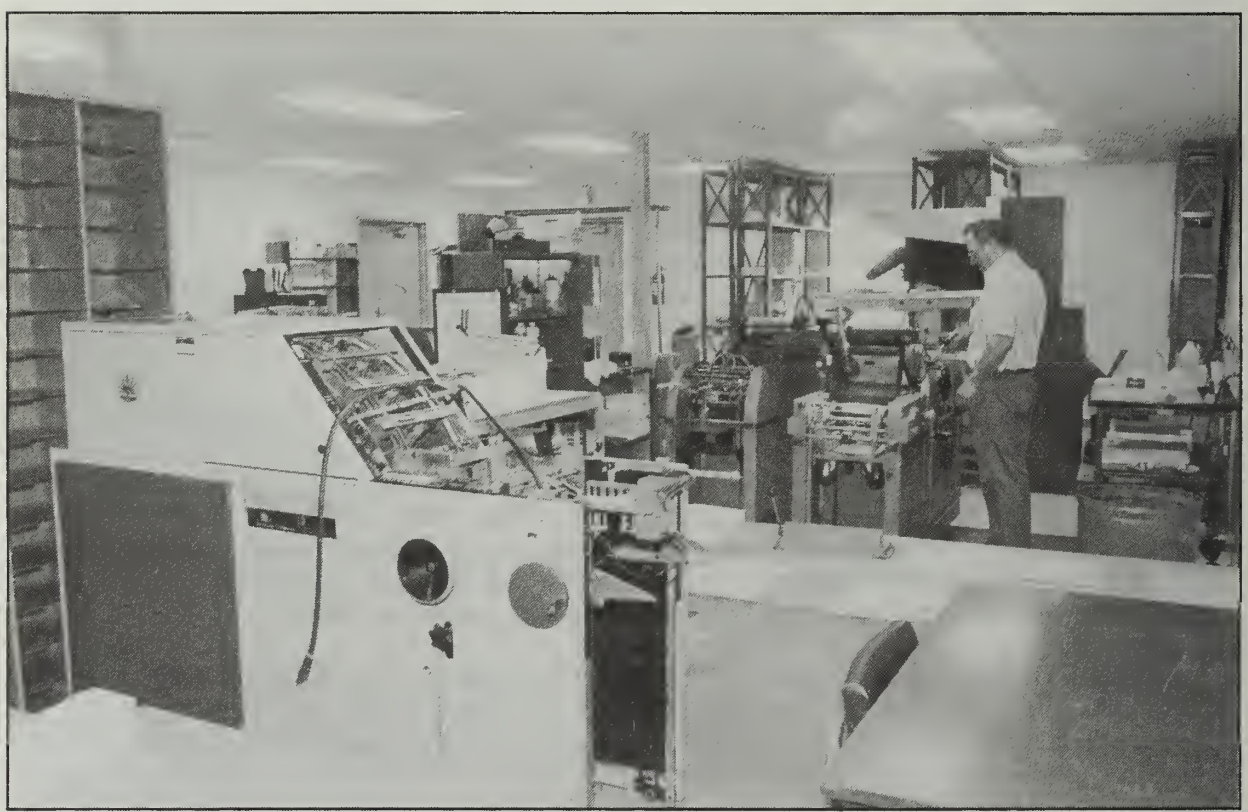
Distribution of Information (Carlisle and Reinertsen). During the past year, the Educational Extension Unit staff responded to 907 mail inquiries by either writing a letter or sending publications. More than 250 long-distance telephone inquiries also were answered, and 146 visitors were provided with information. The Educational Extension staff provided identifications for 32 samples submitted. In addition to the 497 copies of Educational Series booklets mailed during the year, 75 copies of the booklets were distributed at various teacher workshops. This year 22 sets of topographic maps were distributed and 44 separate copies of the booklet, "Guide to the Use of Illinois Topographic Maps," were sent out. Requests for 144 copies of James A. Bier's "Landforms of Illinois" map were filled.

Rock and Mineral Sets (Zelinsky, John Klitzing, McKinney, and Carlisle). The free set of 35 labeled rocks, minerals and fossils distributed to Illinois schools, Scout councils, and other educational groups is designed primarily for classroom display and as an aid in identifying unknowns brought in by students. The sets are distributed at the rate of one per school or one for each 500 students enrolled. During this reporting period 111 complete rock and mineral sets and 12 orders for replacement specimens were distributed to Illinois institutions. In addition, 24 coal ball slices were sent to Illinois schools.

Educational Resources (Reinertsen and Carlisle). A new edition of the Educational Resources listing was compiled by the Educational Extension staff during the year. When printed, this new listing will be distributed to all the nearly 7,500 schools in Illinois. The list includes the educational series, field trip guie leaflets and other publications produced specifically for teachers, and also publications in the Geological Survey's regular scientific series considered useful as background resource materials for teachers.

Educational Exhibits (Reinertsen). This has been an especially busy year for exhibits prepared or coordinated by the Educatinal Extension Unit. Displays about the geology and mineral resources of the state and the research and service activities of the Geological Survey were transported, set-up and staffed by the Educational Unit at the following events during the year; the Illinois Oil and Gas Association Oil Men's Outing, 19 June, Mt. Carmel; the Midwest Environmental Education Conference, 24-27 Sep., Zion; the National

John Klitzing, Harris McKinney, and Mary Jones prepare satellite image maps for shipment at the GSL Annex facility.



Larry Ritchie runs the press in the duplicating shop, now housed in the shop and equipment building.

Council on Geographic Education, 10 Oct., Chicago; the Illinois Science Teachers' Association, 25 Oct., Chicago; and the Engineering Open House, 6-7 Mar., 1987, UIUC. During December, a special display featuring the Satellite Image Maps occupied a prominent place in the lobby of the State of Illinois Center in Chicago.

Lectures (Reinertsen and Stohr). Lectures on the geology and origin of coal and Illinois coal resources were presented for teacher workshops at Willowbrook (9 June), Burr Ridge (21 July), and Beardstown (11 August). Christopher Stohr, remote sensing coordinator for the Geological Survey, and of topogaphic maps for the Champaign-Ford County Eductional District in Urbana on 18 June. They also ran workshops on the Satellite Image Maps at the morning and afternoon conferences for the Urbana District 116 Midwinter Conference (20 February 1987). Reinertsen also presented a lecture on ISGS research and service programs for the Pana Rotary Club.

Other Activities (Reinertsen). The Educational Extension Unit's extensive collection of color slides came to the rescue several times during the year for scientists seeking good field illustrations. Reinertsen continues to represent the Director on the Statewide Advisory Board on Conservation Education of the Illinois State Board of Education.

INFORMATION AND TECHNICAL SERVICES UNIT

Information Office

To meet the needs of people writing, visiting, or telephoning the Survey seeking maps, publications, and answers to questions, ISGS maintains an Information Office. Its staff answers questions and sells maps and publications, which, along with well logs, can now be charged to MasterCard or VISA credit cards.

During January and February 1987, 364 people purchased maps and publications from this office, suggesting that more than 2,184 customers will be served by year's end. The staff also filled 662 mail and 236 telephone orders in those two months. During the same period, the switchboard received 7,431 incoming calls, which would ordinarily project to a yearly total of 44,586 calls. However, with the new telephone system operational March 20, the volume of calls answered by the switchboard operator should decrease.

As part of the University of Illinois' new telephone system, the Survey has upgraded communications; each office now has an individual telephone number that can be reached directly. Replacing the old switchboard is an 8-line telephone instrument from which calls are transferred easily to any campus/Survey telephone. The Survey's new main number is 333-ISGS (333-4747).

Mail Room

The Mail Room is the central receiving and distribution center for office supplies and all ISGS publications and maps. Stocks of all in-print materials are maintained there to fill mail orders and distribute to the staff.

Maps and publications distributed during the reporting period, compared with those for FY86 in parentheses, included:

ISGS publications	25,083 (28,258)	ISGS blue-line maps	2,271 (5,502)
USGS maps	16,730 (17,029)	ISGS maps (including Satellite Image Maps)	12,302 (17,230)

Individual orders filled for the period numbered 4,353, with 3,685 orders for Satellite Image Maps (both state and northeastern) processed separately using a computer system. This system creates numbered labels for pre-printed invoices, mailing labels, and the daily sales log. Those customers' names also are automatically coded and entered into a database that can produce selected mailing lists.

Postage meter use included 63,149 individual pieces amounting to $22,891.71 compared to 70,153 pieces costing $29,747.80 in FY86.

Shipping, receiving, bulk mailing, inventory, filling and shipping mail/phone orders, and other related duties are handled in the Mail Room.

Duplicating Services

The duplicating service shop was moved from the main building to the Shop and Equipment building on July 5, 1986 to free space for the SSC Task Force. Although in smaller quarters, the duplicating shop now has controlled environment, heating and air conditioning, and improved lighting.

During this reporting period, the equipment made 2,293,988 printing impressions consisting of Reprints, monthly Drilling Reports, Illinois Mineral Notes, Environmental Geology Notes, Illinois Petroleum series, Contract/Grant Report, GEONEWS, Mapnotes, fliers, announcements, letterheads, envelopes, and forms. Among the attractive, high-quality, color printing jobs last year were the ISGS newsletter, GEONEWS, Satellite Image Map flyers, and the new Geologic Quadrangle Map announcement. Each presented its own challenges. In addition, the press operator met many deadlines during the year, including production, in a very short time, of lengthy proposals for the Illinois Basin Ultradeep Drillhole project.

Well Log Copy Service

For the third year, the Survey has copied well logs requested by customers in person, by mail, or by telephone. Comparing figures for this reporting period with FY86 figures (in parentheses), the Survey produced 8,113 (14,455) logs; 33,816 (78,807) single data sheets; 78 (185) logs for wells greater than 6,000 feet deep; and 1,597 (927) parts of logs.

From May 1986 until present, the requests for well logs have dropped dramatically, freeing the copyist to assist in the Financial Office on special projects, assist in the Library with daily procedures, and assist with Mail Room duties.

Other Activities

The Information and Technical Services (ITS) Unit worked closely with the staff at the Geological Samples Library (GSL) to relocate the archive and reserve files of the Survey's publications and maps. These documents, stored most recently in the GSL's warehouse, were moved to the attic of the new Shop and Equipment building to increase the GSL's collection storage capacity.

In other cooperative efforts with ITS, the GSL is warehousing some statewide Satellite Image Maps and a large supply of mailing tubes. The GSL staff rolls maps and Survey materials and inserts them into tubes, which efficiently stores them and allows the Mail Room to quickly respond to map orders.

A contract and grant position providing assistance in the mail room was not renewed because of the decreasing workload in the Unit.

WORD PROCESSING CENTER/TECHNICAL RECORDS UNIT

Since the merger of the Word Processing Center and Technical Records Unit, most of the files have been reviewed using the guidelines from the State of Illinois Records Center, and decentralized with the exception of the official files from the office of the Chief. The mail boxes are now located in this Unit to speed the distribution of incoming mail. On the basis of a 2 1/2-week sample, the following mail count was projected for this reporting period: 90,000 pieces of mail handled and 7,584 items received for the Library. Besides handling mail distribution, this Unit is also responsible for vehicle reservations for the staff, the distribution of loan copies for out-of-print Survey publications, typing for the Financial Office, and overflow from the Office of the Chief. Requests to the U of I Physical Plant also flow through this office. The Word Processing Center continues to expand its knowledge and techniques to assist the staff in more efficient ways of typing information. The NBI 64 System was interlinked directly to the Allied Linotype typesetter in the Publications Unit; the whole text or selected pages of an edited manuscript on the NBI is run through a translation table in the typesetter (line speed can vary to 9600 Baud), which translates NBI language to the typesetter language; the manuscript is then ready to be typeset. Also, the NBI 64 System is interlinked with seven personal computers, allowing researchers better access to the NBI System.

In January 1987, a secretarial "floater" position was created. This employee fills in for secretaries on approved time off or where an excess workload develops.

This Unit has also been heavily involved in planning and operationalizing the new telephone system.

LIBRARY/MAP ROOM

The Library/Map Room continued to provide a wide range of services to Survey staff. Journals, bibliographies, acquisitions lists, and other materials were routed to notify staff of work being done in their fields. The librarians consulted with researchers on their specific information needs;

verified and completed citations; prepared bibliographies on requested topics; conducted online literature searches; located articles, reports, and books; borrowed materials on interlibrary loan; and instructed staff in the use of the Library/Map Room and its resources.

This year reference questions again increased dramatically as did circulation. Significant requests included preparation of a map bibliography for Coterminous United States Mineral Assessment Program (CUSMAP), set-up and staffing of an onsite library for the April 1986 Illinois Ultradeep Drillhole Workshop, completion of our part of a union list of field trip guidebooks, and cooperation in the Lincoln Trail Libraries System union list of serials.

The state document shelflist was substantially completed and a program to fill collection gaps in materials from neighboring states was begun. The Library cataloging backlog was eliminated. A continuing effort to improve control of serials resulted in the establishment of a newsletter file. In response to the need for theses on Illinois geology, which are often unattainable or expensive, a program enabling us to receive copies of such theses from schools in Illinois and surrounding states was initiated. To date, University of Illinois at Urbana-Champaign, University of Illinois at Chicago, Southern Illinois University at Carbondale, Northern Illinois University, Northeastern Illinois University, and Ball State University have agreed to participate.

The United States and Canada documents sections were shelfread, weeded, and shifted to provide for anticipated growth in the next 5 years. The Library remains in an overall "no growth" position because of limited space; thus, materials in the collection must be routinely evaluated for retention, and all materials received by the library as donations or gifts must be evaluated before inclusion. This past year, donations included five boxes of materials from Engineering Geology, two crates and five file cabinets of materials from Stratigraphy, three file cabinets of materials from Oil and Gas, two boxes of materials from Mineral Economics, and eight crates of materials from the Annex. In addition, five map case drawers of engineering borings of the Chicago area were received from George Otto of Linden, Indiana.

The Map Room received attention this year. A Library School student from the University of Illinois evaluated Map Room procedures and made recommendations. Historical topographic maps became available and the Map Room filled in its collection, adding more than 2,000 maps. A shelflist of the topographic maps was completed, and work to reduce the map cataloging backlog continued. The physical arrangement of the room was changed to allow for the addition of a large map case and a meeting table while providing a more logical arrangement and improved work area for the librarians. A more flexible meeting area was also created; 168 meetings were held in the Map Room, an increase of more than 250 percent over the past year.

The Assistant to the Librarian in charge of the Map Room resigned on October 31, 1986. At that time, the Assistant Librarian was put in charge of the Map Room. A new assistant was hired in January.

Library Operating Statistics

	1984-85	1985-86	1986-87
Acquisitions: total	2,543	1,862	4,088
Books	100	71	67
State documents	591	442	399
U.S. documents	424	533	576
Canada documents	135	94	176
Miscellaneous documents	401	314	287
Manuscripts	22	43	36
Maps	*868	*359	*2,445
Field notebooks	2	6	---
Photographs	---	---	102
Total items withdrawn	**	256	465
Serials titles and newsletters received	246	260	326
Library Circulation: total	3,063	2,987	3,350
Books, documents, serials, misc.	1,820	2,239	2,756
Maps	1,087	748	502
Field notebooks	45	49	45
Photographs and slides	111	30	47
Visitors	569	413	310
Interlibrary Loans: total	658	812	679
from University of Illinois	522	579	462
from Lincoln Trail Library System	136	233	217
Reference questions	515	1,060	1,427
Online literature searches	48	54	26
Periodicals routed (not counted in circulation statistics)	2,343	1,736	1,071

*Reflects materials processed into the Map Room collection.

**20 journal titles that had been discontinued for 5 or more years were approved for withdrawnal.

HUMAN RESOURCE OFFICE

The Human Resource Office participated in a major effort to gather information from all staff with regard to the ISGS Evaluation and Performance Development System. Information gathered was consolidated, ranked and given to the Research Evaluation Committee and the Administrative Evaluation Committee for review/study and action. The result of this effort is a shortened and simplified process. The new system and forms will be in place for 2 years.

An additional feature of the Evaluation System was the introduction of a three-track system for classifying staff. These career paths relate directly to Research Scientists, Support Scientists, and Administrative Technical staff. The tracks help clarify the career ladder of an individual and allow for choices at certain points in time to allow a change of ladders. Positions were added internally to allow expansion at the top of the ladder; scientists can now attain equivalency with scientist administrators.

A 6-month new-employee evaluation congruent with the new evaluation concepts has been put in place.

A basic management training course was completed for Group, Section, and Unit Heads.

Seven national/regional searches were conducted for major positions which averaged 60+ applicants per search. These included the Geological Records Unit Head, Groundwater Head, Clay Mineralogist, Petroleum Engineer, Public Relations/Communications Specialist, Contracts and Grants Officer, and Lake Michigan Specialist. Approximately 25 local searches were conducted for both scientific and support positions. The response was good in all cases and viable candidates were found.

The Human Resource Office experienced an increase in productivity over the past year. Applications received increased by 47 percent; letters of inquiry regarding employment increased 9 percent; acknowledgment letters written increased 77 percent; ads placed in journals and newspapers increased 57 percent; and there was an increase of 44 percent in the number of candidates interviewed. This was a year of growth for the Human Resource Office.

Activity Measure Table

Information Responses		
Inquiries from staff/public		400
Calls received		1,200
Calls placed		900
Reports		
DENR		31
Workforce analysis (12)		
Affirmative action (13)		
Absenteeism reports (6)		
ISGS		
Staff survey for handicapped needs		1
Staff survey on evaluation system		1
Salary survey		1
OSHA report		12
Status of vacancies		19
Activities		
Applications received		1,088
Response to ads	545	
Others	543	
Letters of inquiry regarding employment		1,641
Acknowledgement letters written		3,529
Ads placed in professional journals or newspapers		58
Professional journals	36	
Newspapers	22	
Announcements posted		80
Candidates interviewed		174
New staff appointments processed		9
Resignations		4
Retirements		2
Requests for appproval to hire		14
Requests prepared for exception to hiring freeze		11
Requests for temporary help		7
Salary progression charts prepared and/or updated		209
Audits of staff attendance records		16
Workshops, training courses, seminars attended		8
Requests for allied agency I.D. cards		135
Contract Personnel Transactions		291
New	(65)	
Transfers	(88)	
Extensions	(78)	
Terminations	(60)	

TECHNICAL DESIGN, OPERATIONS AND MAINTENANCE

Technical Design, Operations and Maintenance Shops provide special services for the Survey that would otherwise be handled through outside, contracted services. These services include design and construction of a variety of instruments and repair and maintenance of existing equipment. Manpower and equipment is available to provide the following services:

- Electrical/Electronics
- Machine Shop
- Woodworking
- Welding
- Automotive
- Plumbing/Piping

Survey shop personnel install and maintain air conditioners, unclog and repair drains, and care for those portions of the Survey physical plant that are not property of the University of Illinois. Shop craftsmen provide custom fabrication and repair of laboratory, field, and scientific apparatus, office equipment, and furniture.

Room Preparation Prior to Organizational Space Changes.

- Prepared room 267 for computers and Computer Research and Services Section staff; removed sinks, utility supply lines, lab table, and fume hood; removed and reinstalled a temporary wall to reconfigure the space.

- Prepared room 237 for expansion of Geological Records Unit files; removed lab tables, sinks, utilities, waste drains, and electrical service; removed temporary wall partitions for use elsewhere. (It is estimated that a $16,000 savings was achieved by completing these tasks in-house rather than contracting the work for completion.)

- Engineered and constructed temporary office walls/partitions to provide five office spaces for the Fermi Lab Task Force.

Room Preparation Prior to Installation of Major Equipment Aquisition Fund (Build Illinois Equipment).

- Removed sink, bench, utilities, and waste drain to prepare space for the Isotopic Mass Spectrometer in room 309.

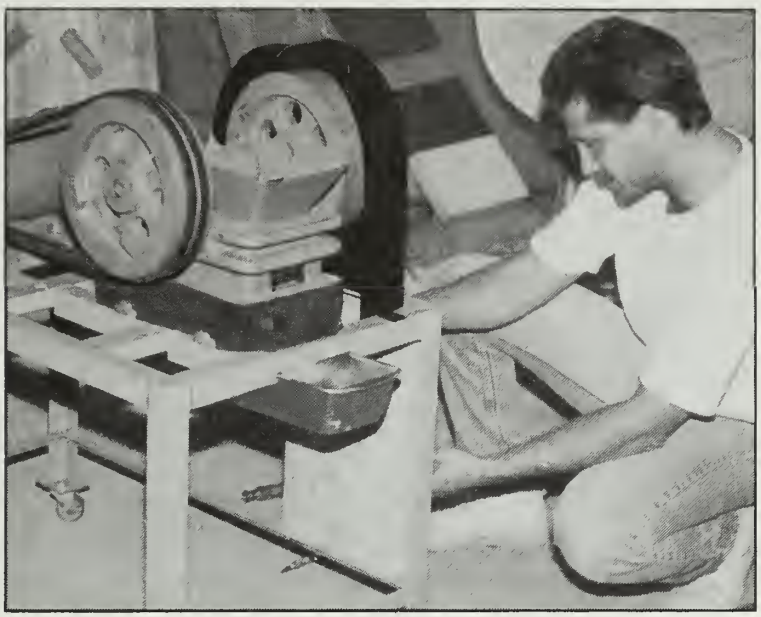
- Designed and provided supervision for the division of space in room 13 prior to the installation of the Scanning Electron Microscope.

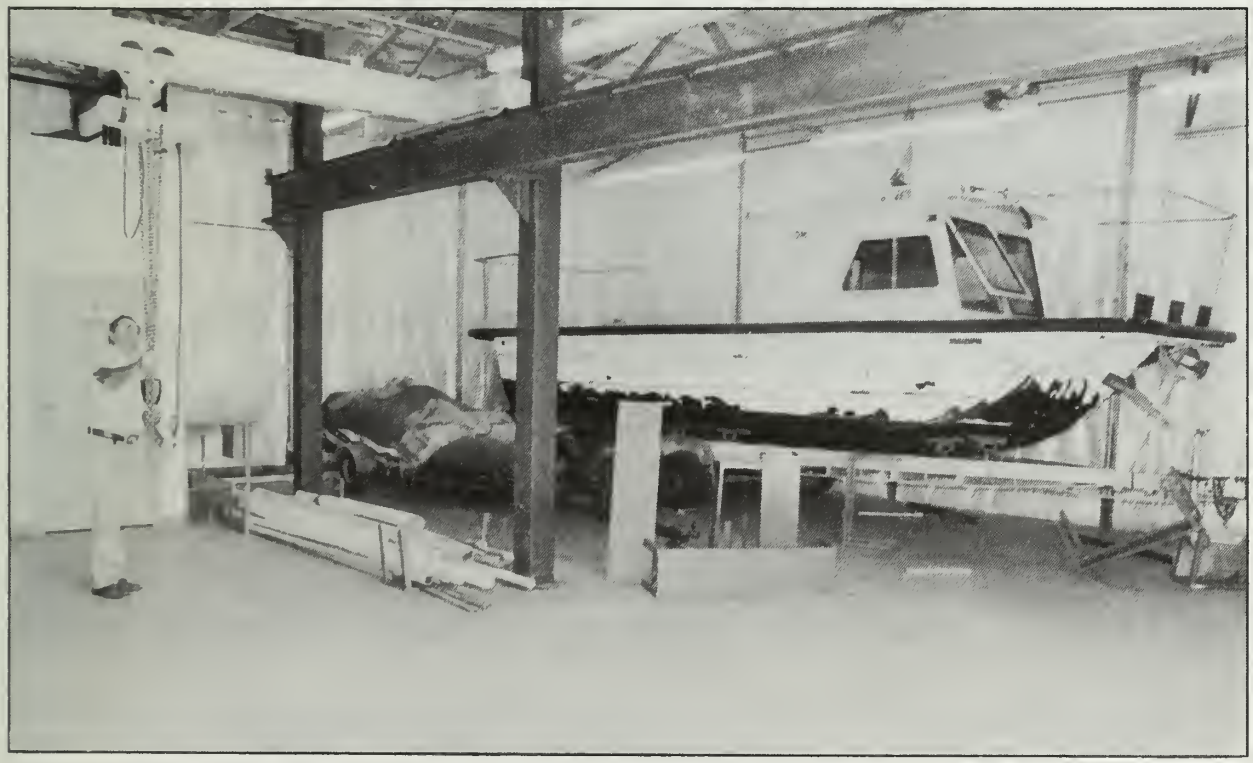
- Coordinated (in-house and UIUC) the preparation of space for the X-Ray Diffractometer and GC Mass Spectrometer.

- Moved AA Spectrometer system from room 323 to 325, revamping the exhaust ducts and Milli-Q-Water System.

Left: Dave Cooley (right), Oscar Richter (top), and Mike Dodd install a stairway—constructed in the shop—that provides access to new storage space in the attic of the shop and equipment building.

Below: Tim Young fabricates a new rock crusher.





Dave Cooley tests the overhead crane, which makes loading and unloading equipment from trucks faster and easier. The boat is used for lakes and rivers research.

Design and Construction of Equipment/Unique Items.

- Designed, engineered, and fabricated an underwater camera protection device for future use in the Lake Michigan Program, a stairway to the attic of the Shop and Equipment Building, and a device for the Chromapro to speed up slidemaking.

- Designed and built several computer tables and a sliding top opening for a low-background radioactive lead cable.

- Designed and machined a bulk pack sampler for the X-Ray Diffraction Unit.

- Constructed dummy tensiometer ceramic cups for the compaction clay liner study.

Renovation/Maintenance of Equipment.

- Cleaned and restored a 50-year-old gravity-flow water ram.

- Designed and installed a hydraulic jack on the tongue of the Mobile Drill Rig at a significant saving over the estimated cost of company installation; redesigned the rear hydraulic levelers.

- Scrounged two large riding mowers from surplus, combining to make one good mower.

- Refurbished many desks, file cabinets, chairs, and shelving units.

- Made systems check on the OMI research vessel for lake and river use.

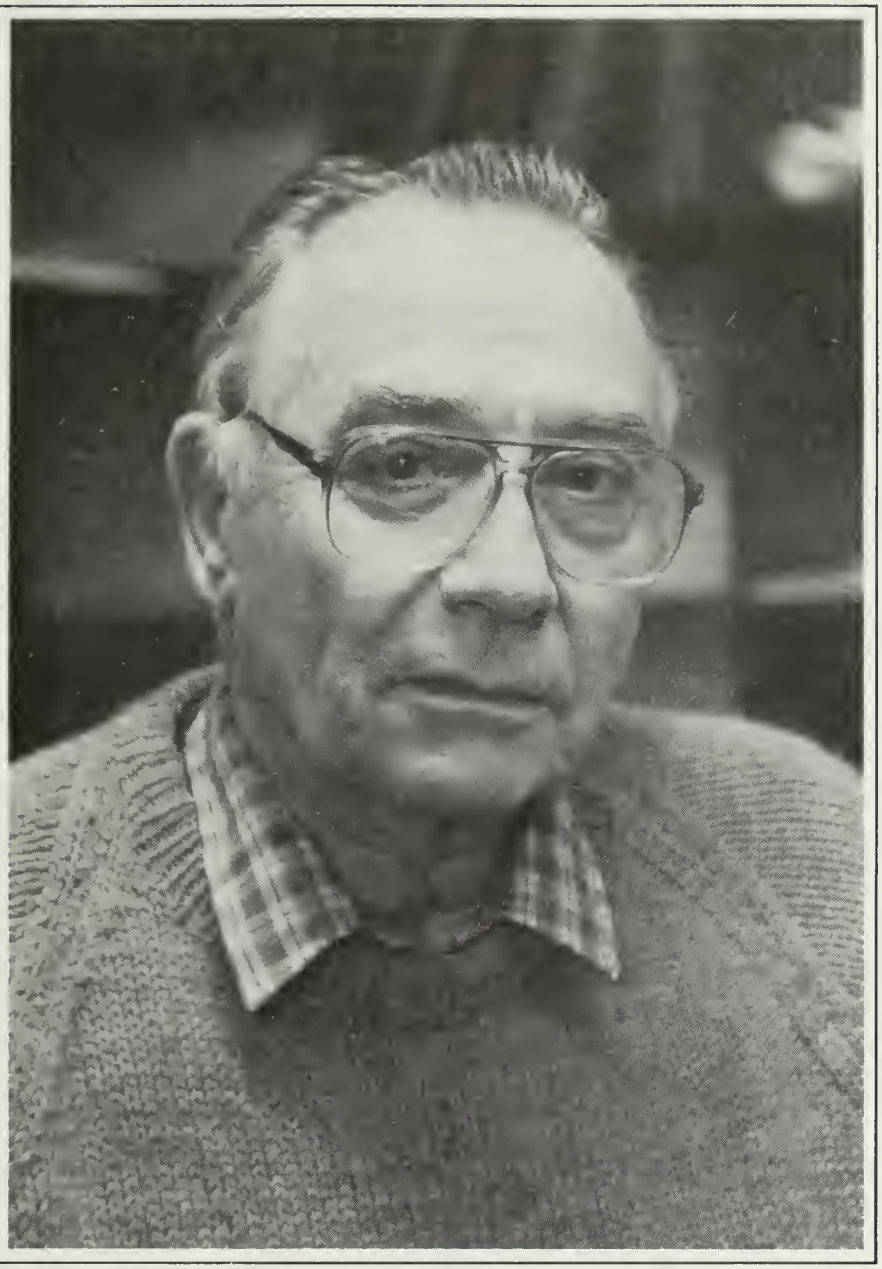
A total of 335 repair, fabrication, maintenance, and moving requests covered by internal work orders were completed during this period. These numbers do not include or reflect the many other jobs done by verbal requests, notes, and the regular maintenance procedures that are required along with the more elaborate shop work.

Electronics Shop

The electronics shop provides electrical/electronic installation, maintenance, and repair to the entire Survey. During the past year, 168 internal work orders were processed. In a year of significant major equipment aquisition and laboratory reconfiguration, these services were of utmost importance. Moreover, equipment downtime and costs are reduced significantly when electronics services are provided in-house.

The electronics shop was heavily involved in site preparation for major equipment, including the GC Mass Spectrometer, Isotopic Mass Spectrometer, X-Ray Diffraction System, X-Ray Fluorescence System, and the Scanning Electron Microscope.

Services were provided to the Applied Research Laboratory to assist in the installation of a new roll-crusher and grinder. Control systems were installed for several research projects.



Recognition and Service

Clay mineralogist Herbert Glass, who retired last August, has been with the Survey since 1948. He still can be found in his emeritus office most weekday mornings. The major focus of his work at the ISGS has been the application of clay mineralogy to the classification and stratigraphic correlation of Quaternary deposits.

RECOGNITION AND SERVICE

HONORS AND AWARDS

Keros Cartwright has been appointed to the Environmental Engineering Committee of the Science Advisory Board of the U.S. Environmental Protection Agency. This is one of four standing committees that oversee technical reviews of Agency programs, research, and regulations.

Charles Collinson received the Society of Economic Paleontologists and Mineralogists Appreciation Award in August for service as editor of the society.

David B. Cooley, Senior Technician and Head of the Technical Design, Operations and Maintenance Unit, and Charles J. Zelinsky, Superintendent of the Geological Samples Library, were selected as the first recipients of the ISGS Distinguished Achievement Award. The award, to be presented on a continuing basis in the future, recognizes those employees whose research ideas, administrative suggestions or other activities have contributed to the stature of the Geological Survey by providing a recognized scientific breakthrough, by significantly reducing operating costs, by bringing credit and recognition to the institution of the Geological Survey and the members of its staff or by otherwise benefiting the ISGS and the State of Illinois.

Joseph A. Devera received his Master of Science in Geology from Southern Illinois University at Carbondale.

J. James Eidel has been named an Adjunct Professor of Geology at the University of Illinois at Urbana-Champaign.

Leon R. Follmer has been appointed to term membership in the Graduate Faculty at the University of Illinois at Urbana-Champaign. This appointment recognizes contributions to graduate student research programs and grants full faculty privileges for directing research programs and serving on University committees.

Mark Grubb and Jerry Miller were selected to participate in and were awarded financial support for the 1986 Indiana University Research Seminar, a team study of seven alluvial fans in the Madison River of Montana.

Morris W. Leighton was appointed by the National Research Council to serve as a member of the Committee Advisory to the U.S. Geological Survey (CAUSGS) for a term ending June 30, 1989. He is also serving as chairman of the CAUSGS Energy Subcommittee reviewing the energy-related research programs of the U.S. Geological Survey.

Robert A. Griffin was promoted to the rank of Full Professor at the University of Illinois.

Beverly L. Herzog was initiated as a full member of Sigma Xi, the scientific honorary society, in April 1986.

Bruce E. Phillips received his Master of Science degree in geology from the University of Illinois at Urbana-Champaign.

William R. Roy has been appointed an Adjunct Assistant Professor of Soil Chemistry in the Department of Agronomy, University of Illinois at Urbana-Champaign.

C. Pius Weibel received his Ph.D. degree in geology from the University of Illinois at Urbana-Champaign.

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SCIENTIFIC AND EDUCATIONAL CONTRIBUTIONS

Professional Societies

Robert A. Bauer has accepted an appointment to the National Rock Mechanics Committee of the Association of Engineering Geologists.

James W. Baxter is a member of the Mining Engineering Committee of the Society of Mining Engineers. He is also chairing the organizing committee for the 23rd Forum on the Geology of Industrial Minerals which will meet in May, 1987 in North Aurora, IL. The ISGS is host for the meeting.

Subhash B. Bhagwat reviewed a paper on graphite markets and imports for the Society of Mining Engineers.

Susan Carol Bradford is a member of the Public Information Committee for the Association of Engineering Geologists and is co-newsletter editor for the North-central Section of AEG.

Ross D. Brower is Historian for the Midwest Groundwater Conference and a member of the Board of Directors of the Illinois Groundwater Association.

Richard A. Cahill is the ISGS representative for the local chapter of the Society of the Sigma Xi. He also serves as a reviewer in the area of Environmental Science and Technology for the Canadian Journal of Earth Sciences

Sheng-Fu Joseph Chou participated in round robin testing of the "Method for 24-hour batch-type measurement of volatile organic sorption by soils and sediments" using 1,1,1-trichloroethane, toluene, and ethylbenzene for the American Society of Testing and Materials.

Chen-Lin Chou reviewed articles for the journals "Organic Geochemistry" and "Geochimica et Cosmochimica Acta."

Charles Collinson is a member of the SEPM Sedimentology Working Group and the GSA Working Group on DNAG Sedimentary Basins of North America.

Joan E. Crockett is treasurer of the Illinois Geological Society.

Heinz H. Damberger is the secretary-treasurer of the Illinois Mining Institute and served as Program Chairman for the Institute's 94th Annual Meeting held in Mt. Vernon, October 15-17. He serves on the Rock Mechanics Award Committee of the Society of Mining Engineers/AIME and on the Nominating Committee of the Coal Geology Division of the Geological Society of America. He also completed two book reviews for publication in Economic Geology, the Journal of the Society of Economic Geologists.

Donald R. Dickerson is Past-President and a Fellow of the Illinois State Academy of Science and a member of the Academy's Council. He also serves as delegate for the Academy to the Illinois Junior Academy of Science and is a member of the board of the Junior Academy. He co-chaired the Science Talent Search Committee, which reviewed 42 scientific papers submitted by high school seniors to the Westinghouse Science Talent Search competition. He selected the winners of the AAAS Awards, the ISAS awards and the Frank H. Reed Memorial

Award for the best scientific paper. He introduced the winners and presented the awards at the Annual Banquet of the Illinois Junior Academy of Science state science fair in Champaign. For the Illinois Junior Academy of Science he serves as chairman of the local committees for Paper Sessions, for Project Judges, and for Auditors for the Outstanding Awards. For the University of Illinois Chapter of the Society of the Sigma Xi, Dr. Dickerson is a member of the Nominating Committee and the By-Laws and Constitution Revision Committee.

William G. Dixon, Jr. is a member of the nominating committee of the Association of Engineering Geologists.

Paul B. DuMontelle and Latif A. Kahn currently serve on the Illinois Coordinating Staff for the 1987 National Symposium on Mining, Hydrology, Sedimentology, and Reclamation to be held December 6-11, 1987 in Springfield, Illinois. DuMontelle also serves on the editorial review committee for short papers presented to the Association of Engineering Geologists.

Henry P. Ehrlinger III was chairman of the Technical Program Committee for the Industrial Minerals Division of the Society of Mining Engineers/AIME for 1986. He organized the preprint program for SME/AIME publications to eliminate duplication.

J. James Eidel is chairman of the Program Policy Committee and a member of the Funding Review Priority Committee for the Society of Economic Geologists. He is also a member of the Steering Committee of the Continental Interior Crustal Studies Consortium (CICSCO).

Leon R. Follmer has been appointed to the editorial staff of Catena, an interdisciplinary journal of soil science, hydrology and geomorphology, and to the Paleopedology Working Group of the International Soil Science Society.

Leon R. Follmer and Dennis P. McKenna were the leaders of Trip 1--Quaternary Records of Central and Northern Illinois--conducted for the American Quaternary Association Ninth Biennial Meeting at the University of Illinois, Urbana, May 31-June 6.

Jonathan H. Goodwin has served for the 11th year as Secretary of the Yellowstone-Bighorn Research Association.

Robert A. Griffin was a member of the Program Committee and a Session Chairman for the Madison Waste Conference at the University of Wisconsin, Madison, WI. He was Chairman of the ASTM D34.02.03 Task Force organized to develop a standard batch adsorption procedure.

Richard D. Harvey is chairman of the Subcommittee on Classification of Coal of the Committee on Coal and Coke of the American Society for Testing and Materials. In that capacity he organized a special seminar on taxes related to lignite and subbituminous coal rank classifications. He also reviewed proposed and existing definitions of coal petrologic terms being compiled for the new edition of the Glossary of Geology to be published by the American Geological Institute.

Bruce R. Hensel is co-editor of the Illinois Groundwater Association newsletter.

Beverly L. Herzog serves as a member of the Editorial Board of the journal Ground Water.

Richard H. Howard is a member of the Geological Committee of the Illinois Oil and Gas Association.

Randall E. Hughes is chairman of the Publicity Committee and a member of the Publications Committee of the Clay Mineral Society. He is also a member of the Mining Engineering Committee of the Society of Mining Engineers/AIME.

Russell J. Jacobson is newsletter editor of the Illinois-Indiana Section of the American Institute of Professional Geologists. He is also president of the Illinois Basin Section of the Computer Oriented Geological Society, an organization he was instrumental in organizing this year.

Latif A. Khan is a member of the Technical Papers Subcommittee of the American Institute of Mining, Metallurgical and Petroleum Engineers. He is also a member of the Program Advisory Committee (Mining Committee and Local Arrangements Committee) for the National Symposium on Mining Hydrology, Sedimentology and Reclamation which will hold its annual meeting in Springfield, IL in December 1987.

Myrna M. Killey served as 1986 Secretary-Treasurer of the Illinois-Indiana Section of the American Institute of Professional Geologists and as Chair of the Section's Regulatory and Legislative Committee. In addition, she serves the Association of Engineering Geologists as Co-Editor of the North Central Section's newsletter, as a member of AEG's Public Information Committee, and as AIPG Liaison.

Dennis R. Kolata is chairman of the Nominating Committee for the Sedimentary Geology Division of the Geological Society of America. He is also a member of the organizing committee for the 1987 meeting of the North-Central Section of GSA to be held in St. Paul. He is co-chairman of Symposia sponsored by the Paleontological Society and the Society of Economic Paleontologists and Mineralogists that will be held at the meeting and he will lead a field trip that will review some of his research on regional correlation of Middle Ordovician K-bentonites. Kolata also serves on the Ordovician System Correlation Committee of the International Union of Geological Sciences.

Morris W. Leighton was elected Statistician of the Association of American State Geologists. He is also chairing the Association's Ad Hoc Committee on Geographic Information Systems.

Rodney D. Norby served as program chairman for the 1986 meeting of the Pander Society, an international research group devoted to studying conodonts, a biostratigraphically important microfossil.

Donald F. Oltz is a member of the Research Committee, the Membership Committee and the Committee on the Statistics of Drilling for the American Association of Petroleum Geologists.

Russell A. Peppers is a member of the Middle Pennsylvanian Working Group of the Subcommission on Carboniferous Stratigraphy of the International Geophysical Union. He also serves on the Midcontinent Pennsylvanian Stratigraphic working group of the Society of Economic Paleontologists and Mineralogists.

Phillip C. Reed was Co-chairman of the Geology Division of the Illinois Junior Academy of Science Annual Meeting in Champaign. He serves on the 1986-9 Editorial Board of the journal Ground Water.

William R. Roy reviewed manuscripts for the Soil Science Society of America Journal, for the Journal Environmental Science and Technology, and for the Journal of Groundwater.

Beverly J. Seyler is president of the Illinois Geological Society and delegate to the American Association of Petroleum Geologists from Illinois.

Neil F. Shimp is Vice Chairman and a member of the Executive Committee of Committee D5 on Coal and Coke for the American Society for Testing and Materials. He is also a contributing editor for the Journal of Coal Quality.

Christopher Stohr organized the Engineering Applications of Remote Sensing Session at the 1986 joint fall convention of the American Society for Photogrammetry and Remote Sensing (ASPRS) and the American Congress on Surveying and Mapping. The session was co-sponsored by the American Society of Civil Engineers. He was appointed to the Alan Gordon Memorial Award Committee of the ASPRS which commends an individual who makes a significant contribution to remote sensing and photographic interpretation.

Conferences and Field Trips

Robert A. Bauer attended the 16th Annual Short Course on Geological Engineering sponsored by the University of California, Berkeley.

R.A. Bauer, D. L. Gross, and K. Cartwright examined tunneling methods used in a section of the Milwaukee Crosstown Interceptor Tunnel and the Jones Island Underground pump station. These facilities are part of the Milwaukee Water Pollution Abatement Program (MWPAP) and are projects similar to Chicago's TARP and the SSC tunnels.

James W. Baxter attended the fall meeting of the Society of Mining Engineers/ American Institute of Mining, Metallurgical and Petroleum Engineers in St. Louis, MO, Sept. 7-10, 1986 and the Annual Meeting of the same organization, Feb. 21-27, 1987, in Denver. Baxter attended the 1986 Symposium on Surface Mining, Hydrology, Sedimentation and Reclamation, Dec. 1-5, 1986, in Lexington, KY, where he presented the paper "Effects of some anionic flocculants and their concentrations on settling rates of coal and underclay slurries." Also in December, he represented the Survey at the Annual Review of Research Activities of the Kentucky Geological Survey. In March of this year, Baxter attended the U.S. Geological Survey's McKelvey Forum, in Denver. In addition to his duties as Head of the Industrial and Metallic Minerals Section, Baxter is serving as Vice Chairman and Coordinator for the 23rd Forum on the Geology of Industrial Minerals to be held in North Aurora, IL in May.

Subhash B. Bhagwat attended the 7th International Industrial Minerals Congress in Monte Carlo, France, April 1-4 1986, where he presented the paper, "U.S. fluorspar industry in a cost/price crunch". He also attended the 30th Annual Meeting of the American Society of Cost Engineers in Chicago, July 1986, where he presented the paper "Economic feasibility of recovering fines from waste streams of minerals processing plants in northern Illinois". At the Fall meeting of the Society of Mining Engineers of the American Institute of Mining, Metallurgical and Petroleum Engineers, St. Louis, MO, Sept. 1986, Bhagwat chaired the session on Economics of High-Sulfur Coal Utilization and presented the paper "Domestic utilization of high-sulfur coals: trends and prospects". He also participated in the deliberations of the Mineral Resources Management Committee of the SME at the meeting. Bhagwat also attended the meetings of the Illinois Mining Institute in Mt. Vernon, IL and the 14th Annual Illinois Energy Conference in Chicago in October 1986.

Susan Carol Bradford attended the short course on Seismology and Engineering Geology in St. Louis by the University of Missouri (Rolla). She also attended a workshop in St. Louis by the Illinois Mine Subsidence Insurance Fund on advanced techniques in data base management and a workshop in Morgantown, West Virginia on surface subsidence caused by underground mining.

Richard A. Cahill attended the annual meetings of the American Chemical Society, April 13-18, New York, and the American Association for the Advancement of Science, May 25-30, Philadelphia. He also attended the conference on "Radon, Radium and Environmental Radioactivity" sponsored by the Illinois Department of Nuclear Safety, Chicago, March 10-11, 1987.

Keros Cartwright presented a paper co-authored with Dennis P. McKenna and Richard C. Berg, "Guidelines for Performance, Groundwater Contamination Studies," to a Soil Science Society of America Workshop in New Orleans, LA.

Chusak Chaven attended the meetings of the American Society for Testing and Materials at El Paso, TX, October 1986, and the 4th Annual Contractors' Technical Meeting of the Center for Research on Sulfur in Coal, Champaign IL, September 1986.

Chen-Lin Chou was invited by the National Academy of Science of Taiwan to be a lecturer at the Workshop on Applications of Neutron Activation Analysis in the Earth Sciences, August 6-12, 1986, National Taiwan University, Taipei and the National Tsing Hua University, Hsinchu, Taiwan, Republic of China. At the workshops he presented talks on "Principals of neutron activation analysis and its applications in the earth sciences," "Application of prompt gamma neutron activation analysis in the earth sciences," "Radiochemical neutron activation analysis," "An introduction to rare earth element geochemistry," and "Neutron activation analysis in coal and petroleum research." Chou presented the paper "Distribution of sodium, chlorine and sulfur in Illinois coals, removal by physical cleaning, and their behavior during combustion" at the 4th Annual Contractors' Technical Meeting of the Center for Research on Sulfur in Coal, Sept. 30-Oct. 2, Urbana, IL. In April 1986, he attended the Annual Meeting of the North-central Section of the Geological Society of America at Kent, OH, where he co-chaired the Symposium on the Geochemistry of Coal and presented the paper "Abundances of the elements in bituminous coals of the Illinois Basin." He also attended the National GSA meeting in San Antonio, Texas, Nov. 10-13, 1986 and the Coal Geology Division field trip, "Geology of Gulf Coast lignites which preceded the meeting.

Mei-In (Melissa) Chou attended 192nd National Meeting of the American Chemical Society in Anaheim, California where she presented the paper "Petroleum source rock potential and crude oil correlation in the Illinois Basin." She also attended the 4th Annual Contractors' Technical Meeting of the Center for Research on Sulfur in Coal, Sept. 30-Oct. 2, 1986, Urbana, IL.

Sheng-Fu Joseph Chou attended the Robert Metcalf Symposium on Pesticide Chemistry and Environmental Toxicology at the Levis Faculty Center, Champaign, and the Illinois Agricultural Pesticides Conference, January 7-8, 1987 at the Illini Union, Urbana, IL.

Heinz H. Damberger attended the fall meeting of the Society of Mining Engineers/AIME, Sept. 7-8, 1986, St. Louis; the 94th Annual meeting of the Illinois Mining Institute, Oct. 15-17, 1986, Mt. Vernon; and the Geological Society of America Annual Meeting, Nov. 6-13, San Antonio.

Stephen K. Danner, Michael S. Summers, and C. Brian Trask attended the 94th annual meeting of the Illinois Mining Institute, Oct. 15-17, Mt. Vernon, IL.

Joseph A. DeBarr, Ilham Demir, Scott L. Ellis, John M. Fox, Patricia L. Fox, Kathleen M. Henry, Trina Kuykendall, C.-L. (Jack) Liu, Eltricia McMillion, David L. Moran, David M. Rapp, Richard B. Read, Michael D. Stephenson, Michael S. Summers, Robin L. Warren, and Alan D. Williams attended the 4th Annual Contractors' Technical Meeting of the Center for Research on Sulfur in Coal, Sept. 30-Oct. 2, 1986, Urbana, IL.

Philip J. DeMaris attended the 4th Annual Contractors' Technical Meeting of the Center for Research on Sulfur in Coal, Sept. 30-Oct. 2, 1986, Urbana, IL, where he presented a portion of the talk on the ISGS aggregate flotation fine-coal cleaning process.

Ilham Demir attended the annual meeting of the North Central Section of the Geological Society of America April 24-25, 1986, at Kent, OH, where he presented the talk "Abundances and leachabilities of sodium and chlorine in lithotypes of the Herrin Coal, Illinois Basin." He also attended the GSA annual meeting, Nov. 10-13, 1986, at San Antonio, where he presented the talk "Modes of occurrence of sodium and chlorine in Illinois coals from selected mines."

Henry P. Ehrlinger III attended the annual meetings of the Society of Mining Engineers of the American Institute of Mining, Metallurgical and Petroleum Engineers, Sept. 7-10, 1986 at St. Louis, and Feb. 21-27, 1987 at Denver. Ehrlinger and Jonathan H. Goodwin are serving as treasurers for the local coordinating committee of the 23rd Forum on the Geology of Industrial Minerals.

J. James Eidel attended the meetings of the Society of Mining Engineers/AIME, September 7-10, 1986, at St. Louis, and February 21-27, 1987 at Denver. He also attended the USGS-sponsored McKelvey Forum in Denver, March 11-13. In November, he attended the annual meeting of the Geological Society of America in San Antonio, TX.

Barry W. Fisher attended the annual meeting of the American Quaternary Association and the associated field trips in north-central and southern Illinois and in SE Missouri. He also attended the annual meeting of the Geological Society of America, Nov. 10-13, San Antonio, TX, and the 1987 annual meeting of the Illinois Quaternary Association held at the ISGS.

John M. Fox attended the meetings of the Illinois Quaternary Association, February 7, 1987, at Champaign, where he presented the paper "Mineralogy and Stratigraphy of Illinoian and Pre-Illinoian tills across south-central Illinois by XRD of fine sand." He also attended the meetings of the Illinois State Academy of Science, April 18-19, 1986, at Edwardsville; the American Quaternary Association Biennial meeting in Urbana; and the Colorado Friends of Mineralogy meeting and field trips in Denver in June.

Patricia L. Fox attended the meetings of the Illinois State Academy of Science, April 18-19, 1986 at Edwardsville and the Colorado Friends of Mineralogy meeting and field trips in Denver in June.

Jonathan H. Goodwin represented the ISGS at the Central Region Cluster Meeting of the U.S. Geological Survey and the Association of American State Geologists, Sept. 15-17, 1986, Lawrence, KS. He also attended the annual meeting of the Geological Society of America, Nov. 10-13, 1986, San Antonio, TX.

Keith C. Hackley attended the Gordon Research Conference at New Hampton, NH, where he presented the talk " Applying stable sulfur isotopes to monitor the mobility of sulfur forms in coal during desulfurization." He also attended the 4th Annual Contractors' Technical Meeting of the Center for Research on Sulfur in Coal, Sept. 30 - Oct. 2, 1986, at Urbana, where he presented two talks: "Integrated study of the chemical and mineralogical behavior of sulfur in coal during pyrolitic and oxidative desulfurization--II" and "Location of isotopically characterized coal samples." Hackley presented the paper "Sulfur isotope data indicate that the two primary sources of organic sulfur in high-sulfur coals are homogenized during coalification" at the annual meeting of the Geological Society of America, Nov. 10-13, San Antonio, TX.

Ardith K. Hansel presented a paper on the age of downcutting of the Chicago Outlet at the 1986 North Central G.S.A. Meeting in Kent, OH, and attended field trips on the Pleistocene stratigraphy in northern Ohio and glacial erosion at Kelley's Island. She served on the local arrangements committee for the Ninth Biennial American Quaternary Association (AMQUA) meeting held in Champaign-Urbana, May 31-June 6, 1986, and organized and led a two-day field trip on Quaternary records in northeastern Illinois and northwestern Indiana for the meeting. She serves as a member of the International Quaternary Association (INQUA) Till Commission and presented a paper on sedimentation in an end moraine complex in northeastern Illinois at the annual meeting of Work Groups 1 and 6 in Amsterdam in September, 1986. She attended the INQUA field workshop, Tills and End Moraines of The Netherlands and Northwest Germany. She also hosted a University of Wisconsin-sponsored glacial geology field trip on the late Quaternary lake level record in the Chicago area in September, 1986. She attended the 99th Annual GSA meeting in San Antonio in November.

Richard D. Harvey attended the meetings of the Committee on Coal and Coke of the American Society for Testing and Materials in Philadelphia and El Paso. He also attended the meetings of the Society of Mining Engineers/AIME at St. Louis, MO., Sept. 7-10, where he presented the paper "Petrographic analysis for use in fine coal cleaning investigations." At a meeting of the Illinois Basin Section of the Computer-Oriented Geologic Society in Evansville, IN, Harvey presented the talk "Illinois coal quality service." The paper "Information system on Illinois coal--II: characterization of samples in the Illinois Basin Coal Sample Program," was presented at the 4th Annual Contractors' Technical Meeting of the Center for Research on Sulfur in Coal, Sept. 30-Oct. 2, 1986, at Urbana. During the year, Harvey also attended the meetings of the Illinois Mining Institute at Mt. Vernon, the Society of Coal Preparation Engineers and Chemists at Benton, IL, and the Society for Organic Petrology at Lexington, KY.

Bruce R. Hensel presented a paper co-authored with B. L. Herzog, E. Mehnert, J. R. Miller, and T. M. Johnson, "Evaluation of Groundwater Monitoring Programs at Hazardous Waste Sites in Illinois," to the Ninth Annual Madison Waste Conference, Madison, WI.

Beverly L. Herzog presented a paper co-authored by B. R. Hensel, E. Mehnert, J. R. Miller, and T. M. Johnson entitled "Evolution and Adequacy of Ground Water Monitoring Networks at Hazardous Waste Disposal Facilities in Illinois" to the Sixth National Symposium and Exposition of Aquifer Restoration and Ground Water Monitoring in Columbus, Ohio. She also presented an invited paper co-authored with K. Cartwright on "Field Permeability Tests on Naturally Occurring Clay Deposits" to the annual meeting of the American Society of Civil Engineers, in Boston, Massachusetts.

Randall E. Hughes attended the 11th Annual Powdered and Bulk Solids Handling and Processing Conference/Exhibition, May 12-15, 1986, at Rosemont, IL, where he presented the paper "Factors affecting the comminution of clay particles in a vibrating bead grinder." He also attended the annual meetings of the American Association for the Advancement of Science, May 25-30, 1986, at Philadelphia, PA, where he presented "Monitoring coal desulfurization by X-ray diffraction analysis." At the 4th Annual Contractors' Technical Meeting of the Center for Research on Sulfur in Coal, Sept. 30-Oct. 2, 1986, at Urbana, Hughes presented "Desulfurization of Illinois coal by in-situ preparation of iron sulfide catalysts." At the 23rd Annual Meeting of the Clay Mineral Society, October 12-15 at Jackson, MS, he presented "Corrensite in the Paleozoic strata of Illinois." Hughes also attended the fall meeting of the Society of Mining Engineers/AIME, September 7-10, 1986, at St. Louis, MO, and the Annual Meeting Februbary 21-27, 1987, at Denver.

Russell J. Jacobson, C.-L. (Jack) Liu, and C. Brian Trask attended the annual meeting of the Geological Society of America, November 10-13, 1986, at San Antonio, TX.

Latif A. Khan attended the 11th Annual Powder and Bulk Solids Processing and Handling Conference/Exhibition, May 12-16, 1986, at Rosemont, IL where he presented the paper "Recovery of fine-grained quartz sands and kaolin from abandoned tailing ponds--a feasibility study." In July 1986, Khan attended the 30th Annual Meeting of the American Association of Cost Engineers at Chicago and from September 7-10, he attended the meetings of the Society of

Mining Engineers/AIME in St. Louis, MO, where he presented the paper "Attempts to combat problems of cleaning fine coal." At the 1986 Symposium on Mining Hydrology, Sedimentology and Reclamation, December 1-5, 1986, at Lexington, KY, Khan presented the paper "Economics of secondary recovery of coal."

Myrna M. Killey presented a paper, co-authored with H. D. Glass, entitled "Principles and Applications of Clay Mineral Composition in Quaternary Stratigraphy: Examples from Illinois, USA," at the symposium of the INQUA Commission on Lithology and Genesis of Quaternary Sediments held September 6 and 7 at the University of Amsterdam, The Netherlands. Following the symposium she participated in a field trip in The Netherlands and West Germany. In addition, she presented a poster session on "Earthquake Hazard Mapping in Illinois Using a Geographic Information System," co-authored with McKay, Krumm, and DuMontelle, at the 29th Annual Meeting of the Association of Engineering Geologists in San Francisco in October, 1986.

Robert J. Krumm presented the talk (co-authored by T. M. Johnson, J. R. Miller, and S. O. Miller) "Applications of a Geographic Information System for a Low-Level Radioactive Waste Disposal Facility in Illinois" at the North Central Geological Society of America Meeting in Kent, OH in April, 1986 and attended a GSA field trip to Lake Erie to observe mass wasting processes along the lake shore. He presented an invited paper (co-authored with E. D. McKay, P. B. DuMontelle, and M. M. Killey) at the Transportation Research Board Annual Meeting in Washington, DC (January 1987). The talk was titled "Earthquake Hazard Mapping In Illinois Using A Geographic Information System." Krumm also presented a poster on the same subject at the Computer Oriented Geological Society-Illinois Basin Section Meeting in November 1986.

Morris W. Leighton presented a paper on "Oil and Gas Research Needs for the 90s" at the Energy and Minerals Conference in Lexington, Kentucky in September 1986. He also presented a talk on "Coal Research at the Illinois State Geological Survey," at the Illinois Mining Institute's annual meeting in Mount Vernon, IL, October 16, 1986.

John M. Masters attended the 22nd Forum on the Geology of Industrial Minerals, May 4-9, 1986, Little Rock, AR; the 33rd Annual Field Conference of the Midwest Friends of the Pleistocene, Aug. 15-17, 1986, Lawrence, KS; and the Fall meeting of the Society of Mining Engineers/AIME, Sept. 7-10, 1986, St. Louis. At the Biennial meeting of the American Quaternary Association, May 31-June 6, 1986, Urbana, IL, Masters was one of several leaders for field trips in central and northern Illinois, May 30-June 1, and in northeastern Illinois and northwestern Indiana, June 5-6.

E. Donald McKay led two field trips for the 9th Biennial American Quaternary Association Meeting in Champaign (May 31-June 6, 1987). The trips--the Wisconsinan and Sangamonian Type-Sections of Central Illinois and Quaternary Records of Southwestern Illinois and Adjacent Missouri--were attended by approximately 130 U.S. and international scientists. He also participated in the conference and workshop on Earth Science Considerations for Earthquake Hazard Reduction in the Central United States and presented a talk entitled "Computers and Computing at the Illinois State Geological Survey" at the first meeting of the Illinois Basin Section of the Computer Oriented Geological Society in Evansville, IN (November 1986).

Edward Mehnert presented two papers, "Geographic Information System (GIS) Application..." co-authored with D. A. Keefer, W. G. Dixon, Jr., and B. R. Hensel, to the 31st Annual Midwest Ground Water Conference in Little Rock, AR; and "Design of Groundwater Monitoring Systems..." co-authored with B. L. Herzog, B. R. Hensel, J. R. Miller, and T. M. Johnson and delivered to the 9th Annual Geo-Aspects of Waste Management Symposium in Fort Collins, CO.

Susan C. Mravik attended the 78th Annual Meeting of the American Society of Agronomy, Nov. 30-Dec. 5, 1986, New Orleans, LA, where she presented the paper "Soil genesis along a topo-chronosequence in East-Central Illinois." She also attended an informal meeting with U.S. EPA officials to discuss deep well injection and the Mt. Simon Sandstone, October 22, 1986, at St. Louis.

W. John Nelson attended the annual meeting of the North-Central Section of the Geological Society of America, April 24-25, 1986, Kent, OH, where he presented the paper "Structural History of the Lusk Creek Fault Zone, Southern Illinois." He also led four geologists from AMOCO on a field trip in the COGEOMAP project area and assisted Steve Marshak, professor of structural geology from the University of Illinois, in leading a field trip for students in southern Illinois. Nelson and Paul Heigold escorted John Davis, a consulting seismologist, in a review of the structural geology and terrain in the region of the "Hub Site" of the Illinois Basin Ultradeep Drillhole.

Rodney D. Norby presented a paper authored with M. L. Sargent and R. L. Ethington entitled "Conodonts from the Everton Dolomite (Middle Ordovician) in southern Illinois" at the Geological Society of America Southeastern-South-Central Section meeting in Memphis in March, 1986. He also participated in a two-day field trip on Ordovician and Silurian exposures in northeastern Arkansas.

Donald F. Oltz regularly attends the monthly meetings of the Illinois Geological Society. During the year he also attended the national meeting of the American Association of Petroleum Geologists in Atlanta, the Interstate Oil Compact Commission in Salt Lake City, Utah, and the Indiana-Kentucky Geological Society. At a meeting of the Big Rivers Geological Society he presented a talk on "The proposed ultradeep drillhole in southern Illinois." At the annual geology seminar of the Illinois Oil and Gas Association, Oltz reviewed current and planned ISGS research programs and proposals that have been or will be submitted to the U.S. Department of Energy to support oil and gas research in Illinois.

David M. Rapp attended the 116th Annual Meeting of the Society of Mining Engineers/American Institute of Mining, Metallurgical and Petroleum Engineers, Feb. 21-27, 1987, Denver, CO.

Richard B. Read presented the paper "Pretreatment of coal to improve pyrolysis performance" at the annual meeting of the ISGS Coal Advisory Committee, May 15, 1986, at Champaign. On May, 13, 1986, at a meeting of the Advisory Group of the Coal Industry Committee at the Center for Research on Sulfur in Coal in Champaign, Read presented a talk on "Optimizing coal cleaning and pyrite removal." At the Engineering Foundation Conference on Fine Coal Cleaning, January 26-30, 1987, Santa Barbara, CA, he presented "The ISGS Aggregate Flotation Fine Coal Cleaning Process" to the group.

David L. Reinertsen conducted special geology field trips in connection with the Midwest Environmental Education Conference, September 24-27, 1986, Illinois Beach State Park, and for an in-service training day for Urbana District 116 teachers.

J. Bruno Risatti attended the annual meeting of the Geochemical Society, Nov. 10-13, 1986, at San Antonio, TX, where he co-chaired the symposium "Microbial transformations in the sedimentary environment," and presented the paper "Sedimentary biogenic acetate and methane: stable isotope relationships." At the Fourth Annual Contractors' Technical Meeting of the Center for Research on Sulfur in Coal, Urbana, IL, Risatti presented the paper "Rates of microbial removal of organic and inorganic sulfur from Illinois coals and coal chars." As a member of the Precambrian Paleobiology Research Group of the Center for Evolution and the Origin of Life at the University of California-Los Angeles, Risatti attended the group's annual meeting in Los Angeles, February 13-17, 1987, and accompanied the group on a research field trip to Querrero Negro, Baja California, Mexico to collect microbial mats, Feb. 18-23, 1987. At the Holderness School, Holderness, NH, in August 1986, he attended the Gordon Research Conference on Organic Geochemistry.

Massoud Rostam-Abadi attended the 15th Annual Conference of the North American Thermal Analysis Society, September 21-24, 1986, Cincinnati, OH, where he presented the papers "The applications of thermal analysis in coal research at the Illinois State Geological Survey" and "Thermal decomposition kinetics of carbonaceous materials: determination of the onset and termination of a reaction stage". At the Eastern Oil Shale Symposium, November 19-21, 1986, Lexington, KY, Rostam-Abadi presented the paper "Co-processing of coal and oil shale: advantages and disadvantages." He also attended the annual meeting of the American Institute of Chemical Engineers, November 2-7, 1986, Miami, FL. At the 4th Annual Contractors' Technical Meeting of the Center For Research on Sulfur in Coal, he presented two poster sessions.

William R. Roy attended the tenth meeting of the Environmental Institute for Waste Management Studies, April 9-10, 1986, Tuscaloosa, AL. He also attended an informal meeting with scientists from the U.S. EPA, October 22, 1986, St. Louis, MO to discuss deep-well injection and the Mt. Simon Sandstone.

Michael L. Sargent attended the annual meeting of the North-Central Section of the Geological Society of America, April 24-25, 1986, Kent, OH, where he presented the paper "Distribution of the Whiterockian Everton Dolomite in Illinois." He also attended a meeting of the North-Central Section of the Association of Engineering Geologists, April 22, 1986, Chicago, IL, and the Symposium on New Perspectives in Basin Analysis, May 8-9, 1986, Minneapolis, MN.

Edward Scoggin attended the first national meeting of state National Cartographic Information Center Affiliates held August 1986, at the USGS Rocky Mountain Mapping Center, Denver, Colorado.

Beverly J. Seyler and Stephen T. Whitaker attended the CEED II meeting, the "Comparison, Evaluation, Exhibition, and Demonstration" of computer-based mapping systems in Denver, CO. They also visited several oil company laboratories to investigate equipment needs for hydrocarbon evaluation and analysis.

Lisa R. Smith presented a poster session, discussion and co-led a field trip for the Midwest Environmental Education Conference at Illinois Beach State Park (Zion, IL), in September, 1986 and co-led a geological science field trip with the Educational Extension Section at Ottawa, in May 1986. She attended the AMQUA biennal meeting at Champaign and assisted on the field trip to northeastern Illinois and Indiana in June 1986. She attended the Geological Society of America, North Central Section Meeting, Kent, OH, and field trip, April 1986.

Michael D. Stephenson attended the Engineering Foundation Conference on Fine Coal Cleaning and Control of Fine Coal Cleaning Processes, January 25-30, 1987, Santa Barbara, CA, where he presented the paper "Desulfurization of Illinois coals by pyrolysis, hydrodesulfurization and magnetic separation."

C. Brian Trask attended the organizational meeting of the Illinois Basin Section of the Computer Oriented Geological Society, Evansville, IN.

Colin G. Treworgy attended the annual meetings of the American Association of Petroleum Geologists in Atlanta, GA, and the Great Lakes Section of the American Congress on Surveying and Mapping at Wood Dale, IL. At the annual meeting of the Illinois-Indiana Section of the American Institute of Professional Geologists, Mt. Vernon, IL, Treworgy presented a talk on "Coal resources in the 80s--a primer for the professional geologist." At the Third Conference on the Use of Computers in the Coal Industry, Morgantown, WV, Treworgy presented the talk, "Geographic information systems: a computer technology for the coal industry." At the Illinois Mapping Advisory Committee technical symposium on "Digital Spatial Data Bases for State and Local Government Programs: Data Standards and Use of Digital Soils Data," in Springfield, IL, he spoke on "Data quality issues of digital mapping at the ISGS."

Janis D. Treworgy attended the Symposium on New Perspectives in Basin Analysis, May 8-9, 1986 at the University of Minnesota, Minneapolis, MN, and the annual meeting of the American Association of Petroleum Geologists.

Robin L. Warren attended the meeting of the North-Central Section of the Society of Economic Paleontologists and Mineralogists and the annual meeting of the Clay Mineral Society, October 12-15, 1986, Jackson, MS. Warren also regularly attends the meetings of the North-Central Section of the Association of Engineering Geologists in Chicago, IL.

C. Pius Weibel attended the annual meeting of the North-Central Section of the Geological Society of America, April 24-25, 1986, Kent, OH, where he presented the paper "Resolution of stratigraphic disarray (Virgilian of Illinois Basin)." He also attended the Biennial meeting of the American Quaternary Association, June 2-4, 1986, Urbana, IL.

Stephen T. Whitaker attended the annual meeting of the American Association of Petroleum Geologists, June 13-18, 1986, Atlanta, GA. He also regularly attends the monthly meetings of the Illinois Geological Society and twice attended meetings of the Indiana-Kentucky Geological Society.

Teaching, Lectures, and Seminars

Charles Collinson was external Ph.D. advisor to Steven Roy in the Geology Department, University of Illinois at Chicago, and was lecturer and advisor to the Department of Geology, Northeastern Illinois University.

Robert A. Griffin presented a lecture on natural leachate attenuation mechanisms at the Workshop on Geotechnical Applications to Waste Disposal, University of Texas, Austin, and a seminar to the Nebraska Geological Survey in Lincoln about the evolving role of the State Geological Survey.

Ardith K. Hansel was a featured speaker at the University of Northern Iowa Math and Science Symposium where she talked on reconstructing late glacial environments. She also gave a slide presentation on ice wedge casts in Finland at the University of Illinois Earth Science Study Group seminar.

Beverly L. Herzog presented a talk entiled "Investigation of failure mechanisms at a hazardous waste disposal site in Illinois" to a University of Illinois combined Hydrosystems and Environmental Engineering seminar in October 1986.

John P. Kempton presented a lecture on the geology of northeastern Illinois to the Great Lakes Forest Soils Conference at the Morton Arboretum and a lecture to the Indiana Geology Department on the SSC at Bloomington, IN.

Myrna M. Killey was invited to give lectures to Ball State University's environmental/engineering geology classes describing Illinois State Geological Survey environmental geology projects. She also lectured to geology majors at Earlham College on the use of clay mineral composition in Quaternary stratigraphy and to Earlham's introductory geology classes on ISGS environmental geology projects.

Dennis R. Kolata is a member of the Ph.D. faculty advisory committees for two students, one at the University of Cincinnati and one at Northern Illinois University. He is also on the Master's Thesis Committee for a student at the University of Illinois.

Douglas E. Laymon taught a geophysical class at Olivet Nazarene University on the uses of the ABEM Terrameter and resistivity interpretive processing techniques.

Donald G. Mikulic presented the talk "Taphonomy and Paleontology of Silurian Trilobites" for Geology Departments at Indiana University-Fort Wayne, University of Wisconsin-Oshkosh, and Lawrence University, Appleton, WI.

Christopher Stohr is teaching two sections of "Introduction to Aerial Photointerpretation" at the University of Illinois Geography Department. He is supervising three graduate students in special studies of aerial photography in Agronomy and Civil Engineering.

Poster Sessions and Educational Exhibits

Karen A. Albrecht and Beverly L. Herzog presented a poster session entitled "Earthen liners: a field study of transit time," co-authored by R. A. Griffin and K. Cartwright, at the annual U.S. EPA symposium on Land Disposal, Remedial Action and Treatment of Hazardous Waste in Cincinnati, OH. The poster was kept for display at the U.S. EPA regional office in Cincinnati.

Larry R. Camp presented the paper "Optimizing coal cleaning/pyrite removal by the use of cis -1,2 dialkylethene sulfonate reagents" at the 4th Annual Contractors' Technical Meeting of the Center for Research on Sulfur in Coal, Champaign, IL.

Brandon Curry and Robert Krumm presented a poster session titled "Altonian (early Wisconsinan) deposits in northern Illinois" at the AMQUA Biennial Meeting in Champaign, IL, June 1986.

Heinz H. Damberger, J. James Eidel, David L. Gross, and Rodney R. Ruch all presented poster talks on ISGS research programs at the joint meeting of the Board of Natural Resources and Conservation and the Board of Directors of the Society for the Illinois Scientific Surveys.

Stephen K. Danner set up and manned a display booth about ISGS coal research programs at the Coal Exposition at Southeastern Illinois Junior College near Harrisburg.

Barry W. Fisher set up and manned a display on ISGS Carbon-14 dating capabilities and accomplishments at the 1986 American Quaternary Association meeting and the 1987 Illinois Quaternary Association meeting.

Craig Gendron, Robert H. Gilkeson, Douglas E. Laymon, George Lin, and David L. Reinertsen provided exhibits and ran demonstrations on behalf of the University of Illinois Geology Department during Engineering Open House, March 6-7, 1986. Gendron, Gilkeson, Laymon, and Lin demonstrated the Geological Survey's mobile geophysical laboratory, collecting seismic data from sledge-hammer "thumps" wielded by visitors. Reinertsen compiled and set up exhibits and posters about the Geological Survey's research programs and about Illinois mineral resources. The displays and demonstrations were designed to highlight for visiting high school students the broad scope of the geological sciences and the strength of the research programs being conducted by the Geology Department and the Geological Survey.

John Kempton presented a poster session, authored by D. R. Soller (USGS) and R. C. Berg, entitled "Applications of geologic mapping in three dimensions" at the AAAS annual meeting in Chicago.

Lawrence B. Kohlenberger attended the 4th Annual Contractors' Technical Meeting, Sept. 30-Oct. 2, 1986, Urbana, IL, where he presented a poster session on "Forms of sulfur: a fractionation scheme for coal pyrolysis products."

Robert Krumm presented a poster session, co-authored by E. D. McKay and J. R. Miller, titled "Computer-aided map preparation at the Illinois Geological Survey," at the Illinois State Academy of Science Meeting, Edwardsville, IL, April 1986.

Carl W. Kruse attended the Gordon Research Conference at New Hampton, NH, where he presented a poster session on "Use of sulfur isotopes to trace forms of sulfur in coal conversion processes."

E. Donald McKay presented a poster session on computer mapping at the CUSMAP workshop in Carbondale, IL, April 1986.

Dennis P. McKenna presented a poster session on Groundwater Issues at the annual meeting of the Association of Illinois Soil and Water Conservation Districts.

Rodney R. Ruch attended Fourth Annual Contractors' Technical Meeting of the Center for Research on Sulfur in Coal, where he presented a poster session on "The ISGS aggregate flotation fine coal cleaning process."

Michael L. Sargent attended the annual meeting of the Geological Society of America, Nov. 10-13, 1986, San Antonio, TX, where he presented the paper "Shatter cones and other shock effects at Des Plaines, Illinois: evidence for meteoroid impact." At an informal poster session at the Bonneterre Symposium, May 1, 1986, held at the University of Missouri-Rolla, Sargent displayed a map of limestone/dolomite ratios in the Eau Claire Formation of Illinois.

Richard H. Shiley attended the Third Annual Pittsburgh Coal Conference, September 8, 1986, at Pittsburgh, PA, where he presented the poster session "Development of the carbon monoxide-ethanol desulfurization process."

Janis D. Treworgy presented the poster session "Illinois Basin--a tectonically influenced ramp during Chesterian time" at the annual meeting of the American Association of Petroleum Geologists, June 13-18, 1986, Atlanta, GA.

C. Pius Weibel presented the poster session "Correlation of midcontinent Virgilian (Late Pennsylvanian) brachiopods" at the annual meeting of the American Association of Petroleum Geologists, June 13-18, 1986, Atlanta, GA.

David L. Reinertsen and Lisa R. Smith prepared and staffed a display about Lake Michigan Shore Erosion and the Geological Survey's responses to the Lake Michigan crisis at the Midwest Environmental Education Conference held at Illinois Beach State Park. Reinertsen also set up and staffed an automated slide presentation on teacher resources available from the Scientific Surveys at the annual meeting of the National Council for Geographic Education, October 10, 1986, Chicago, IL. Other displays set up and staffed by Mr. Reinertsen during the year included a display of map products at the Illinois Science Teachers Association annual meeting, October 25, 1986, and at the annual Oil Men's Outing of the Illinois Oil and Gas Association, June 19, 1986, at Mt. Carmel, IL, and a display about the statewide and northeastern Illinois Satellite Image Maps in the lobby of the State of Illinois Center during December.

J. Bruno Risatti presented poster sessions on "Rates of microbial removal of organic and inorganic sulfur from Ilinois coals and coal chars" and "Microbially enhanced physical separation of pyrite and ash from Illinois coals" at the Fourth Annual Contractors' Technical Meeting of the Center for Research on Sulfur in Coal, Sept. 30-Oct. 2, 1986, Urbana, IL.

Workshops/Training

James W. Baxter attended the U.S. Geological Survey CUSMAP Mineral Deposits Modeling Workshop entitled "Rift-related mineral deposits," presented January 13-16 in Denver. He also attended the USGS Midcontinent Strategic and Critical Minerals Workshop, March 8-10, 1987 in Denver.

Charles Collinson lectured and led discussion groups at a workshop with nearly 300 participants for the North Shore Board of Realtors in Northbrook and at a workshop held for the Lake County Board of Realtors in Gurnee. The workshops were sponsored by the Illinois/Indiana Sea Grant Program.

Joan E. Crockett was coordinator for the April 1986 ISGS-Illinois Geological Society Core Workshop and Field Trip on the Aux Vases and Ste. Genevieve Formations.

J. James Eidel organized, convened, and chaired the plenary sessions of the scientific workshop on the Illinois Basin Ultradeep Drillhole held at the Illini Union April 1-5, 1986. More than 125 scientists representing 25 universities, 6 governmental agencies, and several private companies attended and assisted in preparing the first draft of the Preliminary Plan for Science for the proposed Illinois ultradeep hole. In January, Mr. Eidel attended the USGS-CUSMAP workshop on modeling of "Rift-related ore deposits" where he made a presentation. He also attended the Midcontinent Strategic and Critical Minerals Workshop in Denver, March 8-10. During the fall he attended a workshop to review and discuss the scientific plans for the Appalachian ultradeep drillhole. He also made several presentations about the IBUD proposal at meetings and workshops convened by Deep Observation and Sampling of Earth's Continental Crust (DOSECC), the private, nonprofit consortium that runs the Continental Scientific Drilling Program for the National Science Foundation.

Joyce K. Frost was a member of the Geochemistry Interacting Committee at the Illinois Basin Ultradeep Drillhole Workshop, April 1-5, 1986. She was a co-author, with J. James Eidel and Jonathan H. Goodwin, of meeting reports published in EOS and Geotimes.

David L. Gross participated in the CERN Accelerator School on Applied Geodesy for particle accelerators in Geneva, Switzerland, and visited the tunnels under construction for accelerators in Hamburg and Geneva.

Keith C. Hackley and C.-L. (Jack) Liu attended the Illinois Basin Ultradeep Drillhole Workshop, April 1-5, 1986, Urbana, IL.

Beverly L. Herzog and Vickie L. Poole attended a workshop on skills needed for expert witness testimony at the National Water Well Association annual convention and exposition in September 1986 in Kansas City, MO.

Carol A. Hindman attended the two-week ARC/INFO Training Course at Environmental Systems Research Institute, Redlands, California. She is now working on the environmental siting model of the SSC project.

Latif A. Khan attended workshops on "Fundamentals of agglomeration" given by Dr. Wolfgang B. Pietch, Compactconsult, Incorporated, and on "Explosion protection techniques for combustible dust hazards" given by Joseph Gillis,

Fenwal, Incorporated. Both workshops were taught during the 11th Annual Powder and Bulk Solids Handling and Processing Conference/Exhibition, May 12-16, 1986, Rosemont, IL.

Lawrence B. Kohlenberger advised engineers from the University of Illinois Abbott Power Plant on the testing they should require for their coal samples. He also helped engineers from IIT solve problems they were having in their coal analysis laboratory and advised the director of an independent analytical laboratory on equipment that should be purchased in order to expand the company's coal analysis facilities.

John M. Masters attended a 1-day short course on "Glacial Sedimentary Environments," May 30, 1986, sponsored by the Society of Economic Paleontologists and Mineralogists as part of the meetings of the American Quaternary Association.

E. Donald McKay conducted workshops on the Geographic Information System for geoscientists from the U.S. Geological Survey, the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service, state agencies and others.

Donald F. Oltz attended a workshop sponsored by Deep Observation and Sampling of Earth's Continental Crust, Incorporated, to develop scientific plans for the proposed ultradeep drillhole over the San Marcos Arch in the Texas Gulf coast; he participated in the discussions of Basin Analysis, Geochemistry, and Drilling Technology working groups.

David L. Reinertsen and Christopher J. Stohr conducted workshops on the use of the Satellite Image Map of Northeastern Illinois at the Illinois Science Teachers Association Annual Meeting, October 25, 1986, in Chicago, and the Satellite Image Map of Illinois on June 18, 1986, and February 20, 1987, for teachers in the Champaign-Ford County Educational District. Reinertsen also conducted introductory sessions about coal formation, occurrence and resources in Illinois for three workshops on coal for teachers during the year. Two of the workshops, sponsored by the National Teacher's College of Evanston, IL, were held June 9 at Willowbrook and August 11 at Beardstown. The third workshop, sponsored by the University of Chicago, was held July 21 at Burr Ridge.

William R. Roy attended the U.S. EPA workshop on contaminant flow associated with deep underground injection, June 2-4, 1986, Berkeley, CA; the EPRI workshop on compressed air energy storage, September 23-25, 1986, Traverse City, MI; and the U.S. EPA Second Workshop on deep-well injection, January 12-14, 1987, Las Vegas, NV.

Michael L. Sargent was a member of the Basement Age, Composition and Evolution Study Group at the Illinois Basin Ultradeep Drillhole Workshop, April 1-5, 1986, at Urbana. He also attended the organizational workshop for the Paducah sheet CUSMAP project, April 14-17, 1986, Carbondale, IL.

Beverly J. Seyler was the organizer and principal leader for a core workshop and field trip on the Aux Vases and Ste. Genevieve Formations jointly sponsored by the ISGS, the Illinois Geological Society, and Southern Illinois University-Carbondale, April 4-6, 1986, at Carbondale.

Janis D. Treworgy attended a short course on paleopedology taught by Gregory Retallack at the University of Illinois, February 1987. Retallack's lectures and symposia were sponsored in part by a donation from the Illinois State Geological Survey. Also in February 1987, Treworgy attended a seminar on Sandstone Depositional Systems in the Illinois Basin taught by Paul Edwin Potter of the University of Cincinnati; the seminar was sponsored by the Illinois Geological Society. At the Illinois Basin Ultradeep Drillhole Workshop, April 1-5, 1986, at Urbana, Treworgy was a member of the Basin Analysis working committee.

Stephen T. Whitaker was co-chairman of the drilling technology working committee at the Illinois Basin Ultradeep Drillhole Workshop, April 1-5, 1986, at Urbana, IL.

Public Addresses

Richard C. Berg presented three invited talks on geology-for-planning and groundwater protection to a U.S. EPA seminar in Chicago, an AIPG meeting in Champaign, and the Indiana Geological Survey.

Subhash B. Bhagwat presented a talk on the economic aspects of minerals--markets, uses, extraction, transportation--to Tri-County Tomorrow, a private citizens' area planning group in the Peoria-Woodford-Tazewell County area, December 11, 1986.

Heinz H. Damberger presented a talk on coal development potential of the Peoria-Woodford-Tazewell County area to Tri-County Tomorrow. He also presented a talk entitled "Coal resources and coal's future in Illinois" to the Urbana Kiwanis Club. During the spring he assisted a production crew from WILL-TV's "Prairie Pathways" program in the development of a short television program about the COGEOMAP geologic mapping program in southern Illinois. He also prepared the first draft of a feature article about the southern Illinois mapping program for ENR's newsletter "Illinois Resources."

Robert H. Gilkeson gave a talk on the indoor radon problem to the Kane County Water Association.

David L. Gross lectured on the SSC project to groups such as the Board of SSC for Illinois Incorporated, environmental groups at Fermilab, the Illinois Congressional Delegation, and Rotary Club) throughout Illinois, at national SSC site conferences, and in Washington.

Morris W. Leighton presented a talk on the "CO/ethanol method of coal desulfurization" to the Board of the Renewable Fuels Association in Washington, DC on February 18, 1987.

Stephen S. McFadden gave his presentation "Hydrogeological aspects of landfill siting" to the Champaign Mayor's Environmental Advisory Committee and the Urbana Kiwanis.

E. Donald McKay presented many talks about the technical aspects of computer and Geographic Information System use in geological research to groups such as the Illinois Mapping Advisory Council and the Illinois Coal Advisory Board.

He spoke on the Lands Unsuitable for Mining Program and Computer Mapping of Illinois Resources at the Governor's Conference on Science and Technology in Chicago.

Donald G. Mikulic presented the talk "Silurian reefs of the Chicago area" at a meeting of the Chicago Academy of Science, March 18, 1986. In April 1986 he discussed "Classification of trilobites" at the Mid-America Paleontology Society Exposition in Macomb, IL.

Donald F. Oltz presented talks on "International oil--the control on international oil supplies exercised by OPEC" for the Champaign chapter of AMBUCS and for the Desk and Derrick Club of Olney, IL. In newspaper interviews for the Aurora (IL) Beacon News and the Olney (IL) Daily Mail, he discussed the impact of low oil prices on the oil and gas industry in Illinois and the nation.

Michael L. Sargent presented a talk on new evidence for meteorite impact structures in Illinois to the Loess Club, December 12, 1986, at Springfield, IL.

Janis D. Treworgy led a field trip on "Geology of the Great River Road - Alton to Pere Marquette State Park" for the Mississippi River Natural History Conference, April 1986.

Stephen T. Whitaker presented a talk on "Silurian Pinnacle Reefs in Illinois: a model for hydrocarbon exploration" at a meeting of the Illinois Oil and Gas Association. At a meeting of the Indiana-Kentucky Geological Society he discussed "The Distribution of Silurian Pinnacle Reefs in Illinois." For the Illinois Geological Society he presented a talk on the geology of the desert southwest.

Radio, TV, Press Interviews/Presentations

Subhash B. Bhagwat was a guest on WILL radio's "Focus 580" radio show on January 22, 1987. The call-in show featured a discussion of the Illinois coal industry.

Charles Collinson participated in 37 interviews and programs. Notable were the City Club of Chicago Press Conference; the lecture and press conference sponsored by the Rogers Park neighborhood association; conferences at Northeastern Illinois University and Northwestern University, Evanston; press and television coverage at Wingspread Conference, Racine, WI; the WGN radio interview on the Bill Cullerton Show, Chicago; the Chicago WBEZ Public Radio Interview; television interviews in Chicago with Channel 9, CNN national network; the Channel 2 (CBS) and Chicago Tribune press interview; a radio interview, WABC, New York, ABC; the SISS Press Conference; the WGN "People to People;" and the Lakeshore Mayor's Association Seminar, Channel 5 (NBC). Dozens of recorded press interviews were given and numerous referrals and quotes were published in the suburban press, the Sun-Times, Chicago Tribune, Time Magazine, US News and World Report, Hammond Times, Kenosha and Lansing Michigan newspapers, Reuters, United Press, Christian Science Monitor.

David L. Gross was interviewed on the SSC project by many of the newspapers in the area of the proposed SSC site in northeastern Illinois. When Secretary of Energy John Herrington and President Reagan endorsed the project, national media attention increased; Gross responded to about 20 requests for interviews by telephone.

Ardith K. Hansel was interviewed on the effects of glaciation on Illinois for the DENR radio series.

Stephen S. McFadden, Keros Cartwright, and Beverly L. Herzog were interviewed by a television reporter from WCIA on geologic issues relating to proposed landfill sites for Champaign County.

E. Donald McKay was interviewed by the University of Illinois News Bureau for an article about the GIS entitled "Mapmaker, Mapmaker, Make Me A Map" that appeared in the ILLINI WEEK.

Dennis P. McKenna was interviewed by a television news crew from Effingham, Illinois in May 1986, about the Three-Survey Study of the Environmental Effects of Oil Field Brines in Clay County.

Rodney D. Norby was interviewed by WNUR radio, Evanston, on causes and significance of high lake levels on Lake Michigan.

Richard H. Shiley and others in his laboratory were kept busy this year with press interviews about the carbon monoxide-ethanol desulfurization process. Many of those interviews were generated by the announcement of nearly $100,000 in research support received from the Illinois Corn Marketing Board. Several news stories appeared in Alcohol Week (May 9, May 26 and July 21, 1986) as well as Prairie Farmer, Progressive Farmer and the Champaign-Urbana News-Gazette. News stories appeared on some radio and TV shows and were picked up by Associated Press and United Press International.

Lisa R. Smith presented a poster session and discussion of the Illinois-Michigan Canal National Heritage Corridor, at the request of the Society for the Illinois Scientific Surveys, at a press reception in Chicago in November.

Stephen T. Whitaker was a regular guest on WILL radio's call-in show "Focus 580" this year, appearing three times to discuss the Illinois Basin ultradeep drillhole, problems facing the oil industry as a result of the oil price crash, and general geology.

Governmental Committees

James W. Baxter serves on an advisory committee that is assisting the U.S. Geological Survey in devising a 10-year plan. Also for the USGS, Dr. Baxter reviewed the Illinois portion of an "Intrusive Igneous Rock Occurrence Map." For the U.S. Bureau of Mines, Dr. Baxter reviewed the Bureau's publication on Illinois Mineral Production Statistics and the Illinois Chapter of the Bureau's Minerals Yearbook. Dr. Baxter also is a member of the planning group for the Paducah CUSMAP Cooperative Research Program.

Richard C. Berg serves on the Governor's Groundwater Protection Task Force, the IEPA Groundwater Advisory Panel for Winnebago County, and the NIPC Solid Waste Technical Advisory Committee.

Subhash B. Bhagwat chairs the Economics Interest Group of the Center for Research on Sulfur in Coal.

Ross D. Brower is advisor to the IEPA Underground Injection Control Program in the Division of Land Pollution Control and Counsel to the IDMM regarding their reorganization of the UIC Class II Program.

Dennis D. Coleman is serving as an advisor to the National Science Council of the Republic of China (Taiwan). He also reviews research proposals for the U.S. National Science Foundation.

Charles Collinson is serving as Commissioner on the Chicago Shoreline Protection Commission. He is the DENR representative to the U.S. Great Lakes Commission, and also serves as a member of the Lake Michigan Task Force supported by the City Club of Chicago.

J. James Eidel is a member of the Illinois Department of Conservation Wetlands Advisory Committee.

Robert A. Griffin serves as counsel to the U.S. EPA National Center for Grounwater Research Proposal and Program Reviews; the U.S. EPA Region V; the IEPA Hazardous Waste Regulations and Contaminant Migration; and the Pollution Control Board.

David L. Gross is the Illinois representative to the Intregrated Data Management System work group of the U.S. Army Corps of Engineers. This group of five states and several federal agencies is responsible for implementing the data management portion of the Environmental Management Plan for the Upper Mississippi River system.

Richard H. Howard and Donald F. Oltz are members of the Enhanced Oil Recovery Committee of the Interstate Oil Compact Commission. Howard is also a member of the Potential Gas Committee.

Russell J. Jacobson chairs the Tri-State Committee on Stratigraphic Correlations in the Illinois Basin. C. Brian Trask serves as Secretary of the Committee.

E. Donald McKay is a member of the DENR Prime Policy Committee, which governs the use and development of the Prime computer system, and the Lands Unsuitable Oversight Committee, which coordinates the Lands Unsuitable for Mining Program.

Dennis P. McKenna is a member of the IDENR Conference Advisory Committee on Pests and Pest Management.

J. Bruno Risatti is a member of the Fulton County Steering Committee of the Metropolitan Sanitary District of Greater Chicago. The steering committee advises the MSDGC on the operation of a long-term study of the effects of sewage sludge application to a 17,000 acre area of stripmined land. At a

meeting held by the U.S. Army Corps of Engineers--Chicago District, Risatti and representatives of other state and federal agencies advised the Corps on the scope of the environmental impact statement needed for a proposed "confined disposal facility" and for the dredging of contaminated sediments from the bottom of Waukegan Harbor.

David L. Reinertsen represents the Director of the Department of Energy and Natural Resources on the Advisory Board for Conservation Education of the Illinois State Board of Education.

Governmental Testimony/Presentations

Richard C. Berg represented the Survey at the Department of Nuclear Safety Citizens Advisory meeting on radioactive-waste disposal. He provided information to the Illinois Soil Conservation Service and counsel to the Winnebago County Intergovernmental Solid Waste Disposal Committee.

Richard C. Berg and Robert H. Gilkeson provided testimony at four hearings held by the Illinois Pollution Control Board on groundwater protection.

Richard C. Berg, Ross D. Brower, Robert H. Gilkeson, and Beverly L. Herzog testified at the hearings sponsored by the Illinois Pollution Control Board to present the Illinois EPA Groundwater Protection Plan and obtain public and agency comment upon it.

Richard A. Cahill provided information requested by the Council of Great Lakes Research Managers of the International Joint Commission.

Charles Collinson provided DENR with information for press release and magazine articles and organized photographs and poster materials for a DENR display. He serves as a Commissioner on the Chicago Shoreline Protection Commission and has provided the Commission with maps, photos, a summary of ISGS activities and two lectures; provided maps, diagrams and counseling to the Chicago Department of Planning about flooding and damage dangers; and gave expert testimony in July 1986 to the Chicago Planning Commission Subcommittee on the Lake Front. He presented a lecture at a Lake Level Technical Seminar sponsored by the Chicago Park District at the South Shore Cultural Center in Chicago in September 1986, gave a lecture to Senator Paul Simon's Administrators Conference on Lake Shore Conditions at Northwestern University in October 1986, and spoke on lakefront conditions and legislation for a symposium in Highland Park organized by State Representative Grace Mary Stern.

Charles Collinson, Rodney N. Norby, Thomas H. Shaw, and Lisa R. Smith provided assistance and advice to the Illinois Division of Water Resources of IDOT on problems relating to littoral drift estimates; coarse-sediment demonstration project sites; examination of offshore breakwaters at Wilmette and Lake Forest; evaluation of the effects of a sunken barge at Winnetka; and evaluation of effects of sediment blankets over exposed sanitary lines in Winnetka and Highland Park. They also assisted the Illinois Department of Conservation in continued surveillance of stacked block structures at Illinois Beach State Park; evaluated flooding and other potential damage at Illinois Beach Lodge; and provided depth maps and shore recession maps for northern Illinois Beach and North Point Marina site.

Paul B. DuMontelle provided testimony in Belleville to a hearing of the Subcommittee of the Illinois House Committee on Urban Redevelopment concerning mine subsidence and planning for severe earthquakes in urban areas.

J. James Eidel presented testimony at United States Senate hearings to support the Continental Scientific Drilling and Exploration Act

Robert H. Gilkeson provided counsel to the IDENR and the IPCB about groundwater protection in Illinois. He gave counsel to Lake County on the county plan for groundwater resource development and protection. On the matter of indoor radon problems and sources, he gave counsel to the IPCB, IDNS, the Northwest Municipal Conference, and the Community of Arlington Heights.

Beverly L. Herzog provided advice to the State Attorney General's office on siting groundwater monitoring wells and evaluating data from the wells, which were installed after the state won its suit against the Celotex site in Peoria. Herzog's testimony for the state in the 1985 hearing was heavily cited in the judge's decision in favor of the state. She advised McLean County government officials on the completeness of information filed in an application for a proposed municipal landfill.

Bryan G. Huff prepared the annual report requested by the U.S. Department of Energy/Energy Information Agency on the volume and value of natural gas produced in Illinois and the annual update for Illinois of the Oil and Gas Master Field Code List. Also for the U.S. Department of Energy, a list of all operators who had obtained permits to drill for oil and gas in Illinois was compiled from the Geological Survey's computerized records. As part of a report on the economic future of rural Illinois prepared by DENR, Mr. Huff prepared specialized maps for eight oil and gas fields in western Illinois.

E. Donald McKay assisted the Illinois Emergency Services and Disaster Agency by preparing materials for an earthquake preparedness drill in Richland County. He consulted with the U.S. EPA and IDMM on the design of a computer system for automation of well data for brine injection wells in Illinois. He also assisted state and county governmental agencies to design geographical information systems.

Dennis P. McKenna presented a slide show on "Groundwater in Illinois" and a talk on "Pesticides in groundwater in Mason County" to the Water Resources Committee of the Association of Illinois Soil and Water Conservation Districts. He spoke at the annual meeting of the Association of Illinois Soil and Water Conservation Districts on the topic "Hydrogeologic criteria for land disposal of municipal sewage sludge." He also presented a talk on pesticides in groundwater to agricultural agencies and organizations in Mason County.

Donald F. Oltz reviewed policies and formats for computerization of well permits and other records shared by ISGS and the Department of Mines and Minerals. He also attended a meeting on leveraged research programs at Denver, CO, sponsored by the U.S. Department of Energy.

Steven J. Padovani presented a talk at a meeting of the Kane County Highway Commission to explain the nature of seismic refraction/reflection field work.

Richard H. Shiley, Henry P. Ehrlinger III, and Morris W. Leighton met with officials of the U.S. DOE and Illinois congressmen Richard Durbin and Terry Bruce in Washington D.C. on January 29, 1987, to present the ISGS plan for development of a project that will demonstrate the carbon monoxide/ethanol desulfurization process.

Service on Industrial Committees

Dennis D. Coleman is a member of the Research and Development Council on Advertising Performance of "Research and Development" magazine.

Heinz H. Damberger is a member of the Editorial Board of the International Journal of Coal Geology.

E. Donald McKay consulted with several industrial representatives about the design of computer mapping facilities and databases.

Public Service

J. James Eidel is a member of the Board of Directors of the Champaign County Audubon Society.

David Gross served as Chair of the Campus Charitable Fund Drive of the University of Illinois. The staff of the University contributed more than $425,000 to this coordinated United Way and Combined Health Appeal compaign. The Surveys were three of 38 Sections and all three exceeded goals, contributing a total of more than $19,000. All of these figures are new highs. The campus total was up 12.5 percent over the previous year. David Gross is serving a year as President of the Urbana Rotary Club. He has lectured on the organization of charity fund drives to United Way groups in Champaign, Bloomington, and Springfield.

Mark Grubb is the senior volunteer flight instructor and tow pilot for the University glider club. He serves as the pilot for the ISGS photo flights of the Lake Michigan shore and for aerial reconnaissance of the SSC study area.

Beverly L. Herzog serves as CPR Chairperson on the Board of Directors for the DeWitt County Chapter of the American Red Cross. She was the 1986 DeWitt County chapter delegate to the American Red Cross National Convention in Indianapolis. She teaches community CPR and standard first aid classes in DeWitt and Champaign Counties. She was presented awards by both DeWitt and Champaign County Red Cross chapters for 500 hours of service and for commitment to community teaching, respectively.

Jennifer Hines is the graduate student member of the University of Illinois College of Education Program Committee. The committee is responsible for establishing program requirements for all graduate students.

Randall E. Hughes was a Section Leader for the United Way/Combined Health fund-raising drive at ISGS.

Kathleen W. Miller served as a judge for the Holy Cross School Science Fair in Champaign and also judged projects in the biochemistry/microbiology division at the State Science Fair of the Illinois Junior Academy of Science at Champaign.

John M. Masters serves as judging chairman for the earth science division for the State Science Fair of the Illinois Junior Academy of Science at Champaign. Other judges at the science fair included Jonathan H. Goodwin, Michael L. Sargent, Beverly Seyler.

Michael L. Sargent served as a judge at the Mahomet-Seymour Science Fair.

Activity Measures

ACTIVITY MEASURES

Background

All Illinois state agencies are required to provide activity measures as part of their annual budget presentations to the legislature. Selected activity measures also are included in the Governor's report on the Illinois state budget. Internally, we use a wide range of activity measures to gauge how effective we are at reaching the public with our information and services. The measures are also helpful indicators of where our research and service staff are applying their greatest energies and to what degree we may need to adjust or reshape our program, budget, or organization.

Although records are kept throughout the year on such items as publications distributed or numbers of sponsored research projects, some of our activity measures are based on annualized calculations from samples counted during a representative 1- or 2-month period. In most cases, this limited sampling provides a sufficient level of accuracy. Last year, sales of the Satellite Image Map of Illinois during a frenzied 2-month period around Christmas created a huge increase in the number of publications distributed in comparison to the levels of previous years. This year there was no Christmas rush and total number of publications distributed fell significantly. However, the numbers remained significantly higher than 1984-85 levels before the advent of the satellite maps. Apparently, the Satellite Image Maps, the SSC siting studies, our response to Lake Michigan shoreline erosion problems, the Illinois Basin Ultradeep Drillhole and other "high-profile" activities during the year have kept the Geological Survey in the public eye and increased public awareness of the resources available from us.

On March 23, 1987, the private branch exchange switchboard was removed from the Information Office where it had stood for more than 40 years. One of the activity measures we have used in the past was a count of the number of telephone calls handled through the switchboard. Obviously, this count will no longer be meaningful, and this will be the last year that the number of incoming telephone calls will be tabulated. The computerized accounting of telephone calls offered by the new system may provide new, more efficient ways of measuring this activity, and we will be investigating this opportunity during the coming year.

Measures

Research Activities. ISGS scientists reported 118 active state-funded research projects in progress during the year, 18 fewer than were reported last year. Of these, 61 were in the area of Mineral Resources, 23 in Environmental Geology, and 34 in the area of General and Basic Research. This ratio reflects, in part, the significant contract and grant support that is available for research in environmental geology, and in part, an increased emphasis on mineral resources research through the CUSMAP cooperative program. While the number of state-funded research projects decreased by 18, the number of sponsored research projects increased by 15, from 90 in 1985-86 to 105 this year, almost a 1-for-1 exchange. Of those projects, 53 (50% of the total) were in the Environmental Geology area, 29 in the Mineral Resources, and 23 in General and Basic Research. Approximately 47 percent of all the active

research projects at the Geological Survey are funded through contracts and grants. During the year, ISGS scientists wrote 75 proposals to state, federal, and private agencies to seek funds for research projects.

To present our research information to the public and the scientific community, we published a combined total of 184 new articles, reports, maps, and abstracts in our own publication series and in other forums such as refereed scientific journals, proceedings volumes, guidebooks, and pamphlets. The Information and Technical Services Unit distributed 25,552 copies of ISGS publications, 14,573 copies of ISGS maps, and 8,113 copies of U.S. Geological Survey map products. The total of 40,095 ISGS publications and maps distributed is 23 percent lower than the extraordinary numbers in 1985-86, but almost 13 percent greater than the 35,546 publications distributed in 1984-85. Distribution of U.S. Geological Survey map products declined by more than 100 percent compared to last year's extraordinary increases, returning to about the same level as in 1984-85.

Public, Government, and Industry Services. The accompanying table shows selected measures of our services provided during the year, distributed by program areas.

- Information Responses. ISGS scientists hosted 6,860 visitors in their offices this year to exchange scientific information. They also sent out 6,714 letters to answer inquiries and responded to at least 15,860 telephone requests for information. The Information Office, in a 2-month survey period in January and February, handled 7,431 incoming telephone calls through the switchboard, which projects to an annual total of more than 44,500 telephone calls to the Geological Survey. About two-thirds of these calls are business calls that are not requests for scientific information or services. The number of visitors at the Geological Survey dropped by about one-third from last year's total. This decrease reflects both a 50 percent drop in the number of visitors to the Information Office, because of the absence of a Christmas rush for Satellite Image Maps this year, and a nearly 50 percent drop in the number of visitors to the Geological Records Unit. GRU reported only 1,495 visitors this year, compared with 2,921 last year, but received 3,870 telephone inquiries, 716 more than last year. The Unit handled only 40,566 files for visitors this year, a reduction of more than 50 percent in comparison to last year's numbers. This approximately 50 percent reduction in activity in the Geological Records Unit comfirms the trend that began in November 1985 when oil prices declined sharply. The Geological Samples Library distributed 513 sample sets to 287 visitors for examination and study, and 275 sets for study by ISGS staff members.

- Identifications, Analyses, and Reports/Memos. To conduct various research and service projects during the year, ISGS scientists completed at least 28,696 technical and chemical analyses. This total includes chemical analyses performed on 5,270 samples of rocks, minerals, soils, and coals that involved 32,097 determinations of separate elemental concentrations or other chemical or physical properties. Other technical analyses included more than 6,000 samples analyzed by X-ray diffraction to determine mineralogical content; 7,500 determinations of particle size or suspended sediment concentra-

tions; 539 drillhole and sample sets stratigraphically logged and 59 drillholes logged by geophysical methods; 565 separate identifications of rock and mineral specimens for visitors; and 195 electrical earth resistivity surveys and 856 shallow seismic survey lines totalling more than 80 line miles. To report the results of these analyses, and for other purposes, ISGS scientists prepared 1,183 unpublished reports, memoranda, and other materials, including 330 computer-plotted maps, 12 ground instability reports, 137 mine subsidence reports, 95 groundwater reports, 18 deep-well disposal reports, 35 waste-disposal site reports, and 62 high-volume well reports. In the Computer Research and Services Section, ISGS staff wrote 257 computer programs, digitized 102 maps, and encoded, entered, and verified data for 63 different projects.

Continuing Scientific/Educational Contributions. Geological Survey staff members presented 156 papers and poster sessions at various learned and professional society meetings, and participated 126 times in field trips and conferences. We also presented 96 lectures, seminars, and tutorials for colleges, high schools, elementary schools and other educational groups, provided formal and informal advice for graduate students 96 times, and participated in or led workshops or training courses 97 times during the year. Our scientists held 111 offices or committee seats in professional organizations and reviewed 199 manuscripts and abstracts for learned journals and other outside publications. The Educational Extension Unit distributed 111 rock and mineral sets, 12 partial sets, and 24 coal ball slices to Illinois schools. They also distributed 497 copies of the Educational Series booklets, 22 copies of the topographic mapping exercise, and more than 400 copies of the field trip guide leaflets.

Public, Industry, Government Contributions. Survey staff members presented 75 popular talks to civic groups and other organizations, gave 137 interviews to the press, presented testimony at 5 governmental or public hearings, and served on or made presentations to 35 governmental, industrial, and public committees. These all are included in the 408 talks and presentations summarized in the following table.

Illinois State Geological Survey Selected Activity Measures 1986-87

	Mineral Resources	Environmental Geology	General and Basic Research	Administrative Services	Total
Reports/maps published (distributed)	85	58	35	6	184 (40,095)
Unpublished reports, memos, and other responses	407	571	205	0	1,183
Lectures, talks, presentations, and public addresses	132	144	128	4	408
Workshops, classes, and seminars	41	91	52	9	193
Visitors and office conferences	2,599	1,267	354	2,640	6,860
Telephone inquiries	7,016	4,748	2,136	1,960	15,860
Letter inquiries	911	701	223	4,879	6,714

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